JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVIII.] JULY, 1869. [No. 1

EDITORIAL.

ITEMS AND NOVELTIES.

Gunpowder Pile-Driver.—On page 218 of our last volume, we gave a full description, with an illustration, of this remarkable machine; we now give the report of some experiments made under the direction of Chief Engineer Wood, of the U. S. N.

Philadelphia, June 15th, 1869.

GENTLEMEN:—Having been present by invitation, at the shipyard of John W. Lynn, Esq., of this city, on the 14th inst., to witness the working and operation of Thomas Shaw's patent hammer for driving piles by the agency of gunpowder, and requested to report the action and details of the operation, we herewith briefly state the result to have been as follows:—

The pile-driving engine was of the usual form, being two vertical posts resting upon a platform, and readily moved as required.

The height of the posts was 48 feet, fitted with guides, and a frictional V-shaped rod, under the control of the operator, so arranged as to arrest the ram working in the guides, at whatever point desired.

The ram, working in the guides, was fitted with a plunger, extending through its centre and projecting above and below it about two feet.

The top of the pile was protected with a cast iron cap-piece, 30 inches deep, on the bottom of which was a recess resting upon and following it down during the process of driving it; into this cap-piece, upon its upper portion, was a cylindrical aperture, 4½ inches in diameter and 18 inches deep, into which the lower plunger, attached to and forming a part of the ram, was fitted.

At the upper portion of the frame was located a cylinder, into which the upper plunger of the ram was fitted.

The operation being, that when a pile was placed in position to be driven, and but little space afforded for striking a blow, the upper plunger entered the cylinder at the top, compressed the air, and, by its elasticity, gave additional force to the ram in its descent upon the pile.

The hammer was put in operation by hoisting it up 6 to 8 feet, in which position it is held by the friction-bar, operated from below by a suitable lever. A cartridge is then thrown into the cylinder of the cap-piece, resting upon the top of the pile, by an attendant; when the hammer is released and falls, the plunger enters the cylinder of the cap and explodes the cartridge, which forces up the hammer a distance of from 7 to 9 feet, depending upon the size and weight of the cartridge.

The reactionary effort in projecting or throwing up the ram being utilized in forcing down the pile.

The weight of the ram, with the plungers, was 675 pounds.

The pile which we saw driven was very nearly parallel throughout its length; 12 inches in diameter, in the centre, and 32 feet long.

When placed in position, with its lower end pointed, eight blows were first given, to show the gentlemen present the operation of the machine, forcing the pile down 36 inches.

Nine (9) blows were then struck, forcing down the pile 20½ inches. Time consumed, 15 seconds.

Next, twelve (12) blows were given, forcing down the pile 22½ inches. Time, 15 seconds.

Seven (7) blows followed, forcing down the pile 30½ inches.

The hammer then rested a distance of one foot above the head of the pile, at which point a blow was struck, which forced down the pile 1 inch.

At this stage of the operation, a cartridge one-half heavier than those previously used was placed in the cylinder, and, when exploded, forced the pile down 5½ inches, followed by two successive blows, when the pile was driven 12¼ inches.

One blow, with similar cartridge, was struck, forcing down the pile 4⅜ inches.

The experiment was then made by striking the pile with the ram falling the same distance, 8 feet, from which it was thrown by the cartridge, dispensing with the cartridge, when the pile was driven only ⅛ inches. The blow in this case being similar to that given by an ordinary pile-driving engine with a ram of 675 pounds falling through a distance of 8 feet.

The next blow was made similar to the last (with the use of the cartridge), the ram falling through 9 feet 6 inches, when the pile was driven 4⅜ inches, as in the former case.

A hard and well-seasoned oak block was placed upon the cap resting upon the pile, upon which the plunger fell when powder was not used.

The next experiment developed the rapidity with which the operation of driving piles with this machine could be prosecuted.

The pile was driven 10 feet 6 inches in 55 blows. Time consumed, 1¼ minutes.

Eleven (11) blows were next given, forcing down the pile 26½ inches.

Twenty-nine (29) blows were next given in 40 seconds, driving down the pile 9 feet 2 inches.

The pile was next driven 2 feet, which completed the total distance driven, viz: 30 feet, of which no record was kept.

On the completion of the work, the cap was lifted off the pile, when the head was found to be in as perfect a condition as if, practically, no force whatever had been applied to it in forcing it through a distance of 30 feet in stiff, hard soil. It may be proper to add, in conclusion, we consider this novel application of gunpowder to be an unqualified success, for the purpose of driving

piles, promising, as it does, a saving both of time and labor, which should commend its use to all who require machines of this character. We are respectfully your obed't servants,

W. W. W. WOOD,
Chief Engineer U. S. N.

To Messrs.
THOS. SHAW,
W. H. RICHARDSON,
W. L. GILROY,
JNO. W. LYNN.

H. L. HOFF,
Eagle Iron Works, Philadelphia.
T. J. LOVEGROVE,
Inspector of Steam Boilers, Philadelphia.

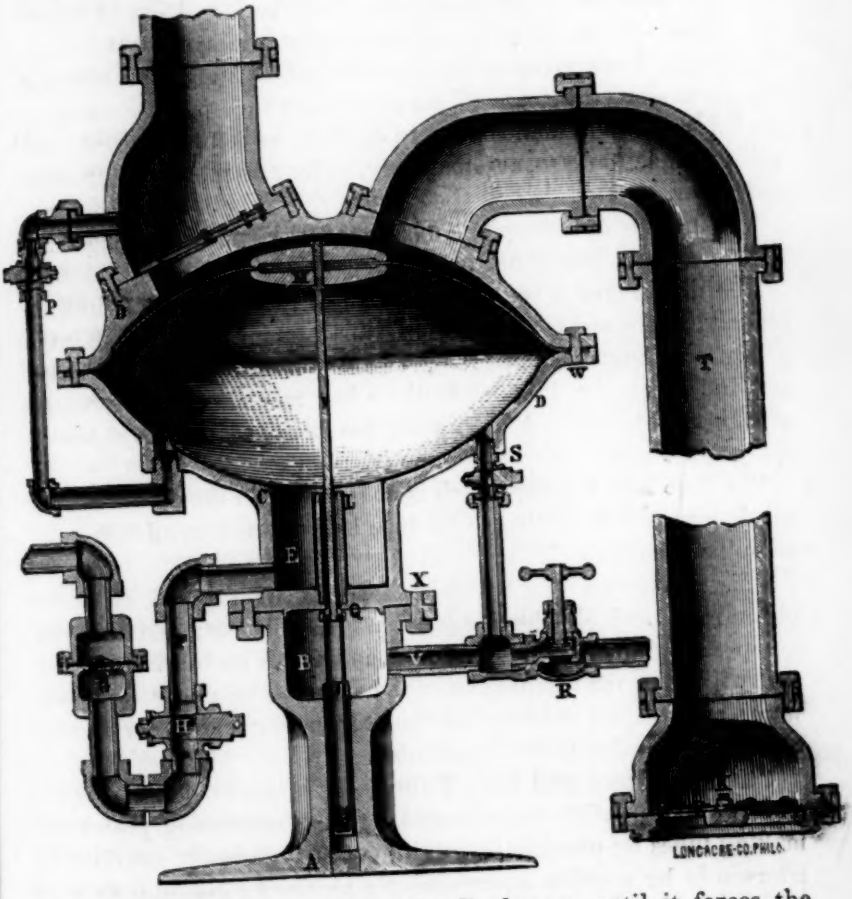
New Pumping Engine. By Messrs. Shaw & Justice.—At the last meeting of the *Franklin Institute*, this apparatus was exhibited, and described by M.. Thomas Shaw, as follows:—

The appliances for pumping water are perhaps more numerous than those for the accomplishment of any other single purpose, and it might naturally be supposed that modern pumps could neither be cheapened nor simplified, to any great extent, for the reason that the hydraulic engineering talent of the world, for the past half century, has been spent in improving these machines; yet, notwithstanding this, I believe that the pump I am about to explain, when constructed of large size, can be furnished at less than one-half the cost of any other pumping engine, will perform the same duty, and possesses not a tenth of the complication of parts.

This engine is constructed in the following manner:—two hemispheres, C and D, are united by bolts, W, and between them is a cotton duck and gum diaphragm, N, clasped in the centre by metal discs, M, secured to valve-stem, I. A is a cast iron base, united to hemisphere, C, by bolts, X, forming a steam-chest, B. V is a steam-pipe leading from the boiler, and R and S are valves to control the same. J is a valve, having its seat at Q, and is operated by the valve-stem, I, as hereafter described. T is the inlet-pipe, provided with ordinary valves, K. U is the outlet-pipe, provided with a valve. P is a pipe, provided with a stop-cock, to lead water to the injecting nozzle, O; said nozzle is provided with a valve opening inward. E is the hot well for the collection of the condensed steam. L is a pipe for conveying steam above any water contained in the hot well. F is a pipe for conveying water from the hot well, and is provided with a valve, G, and stop-cock, H.

The engine is started in this wise: steam is allowed to pass from valve S into the hemispherical chamber beneath the diaphragm, N,

until all the air contained in said chamber is blown out through pipe F, when the steam is shut off at valve S. When the hemispherical chamber is relieved of pressure below that of column of water in pipe, P, jets of water are thrown from nozzle, O, condensing the steam and creating a vacuum. The only place to fill this vacuum is by the inlet-pipe, T, through which the water rushes and fills the



hemispherical chamber above the diaphragm, until it forces the diaphragm to its lowest position, at which time the valve-stem will have reached the bottom of valve, J, and press upon a spring contained therein, forcing the valve from its seat and allowing the steam to pass through pipe L, beneath the diaphragm, forcing all the water out of pipe U, until the diaphragm shall have arrived at

its highest position, at which time the button in lower end of valve-stem will have caught on the top of valve J and lifted it to its seat, where said valve will be held by the pressure of steam until again pushed off. In the meantime, during the ascent of the diaphragm, the injecting-nozzle, O, will cease injecting water at the instant the steam enters, by reason of the pressure of steam, and the hot water from the previously condensed steam will be forced out of pipe F, by reason of the pressure of steam upon the same. When the diaphragm has arrived at the afore-described highest position, and the valve shuts the steam off, a vacuum will be formed by reason of the injected water; and the pump operates as before described, and will continue to do so, automatically, so long as supplied with steam and water.

The interior of hemisphere C is coated with non-conducting material, to prevent loss of heat.

The diaphragm is constructed of thick gum and cotton duck, in separate layers, and is used only as a partition for heat; it floats in the pressure without strain, as the pressure is the same on both sides; and, in this respect, it is not unlike a belt traveling in the pressure of our atmosphere. A continued use of eight months shows no appreciable wear.

We have here a pump which is constructed in the foundry, so to speak, since all the fitting to be done is in the nature of bolt-holes and pipe apparatus.

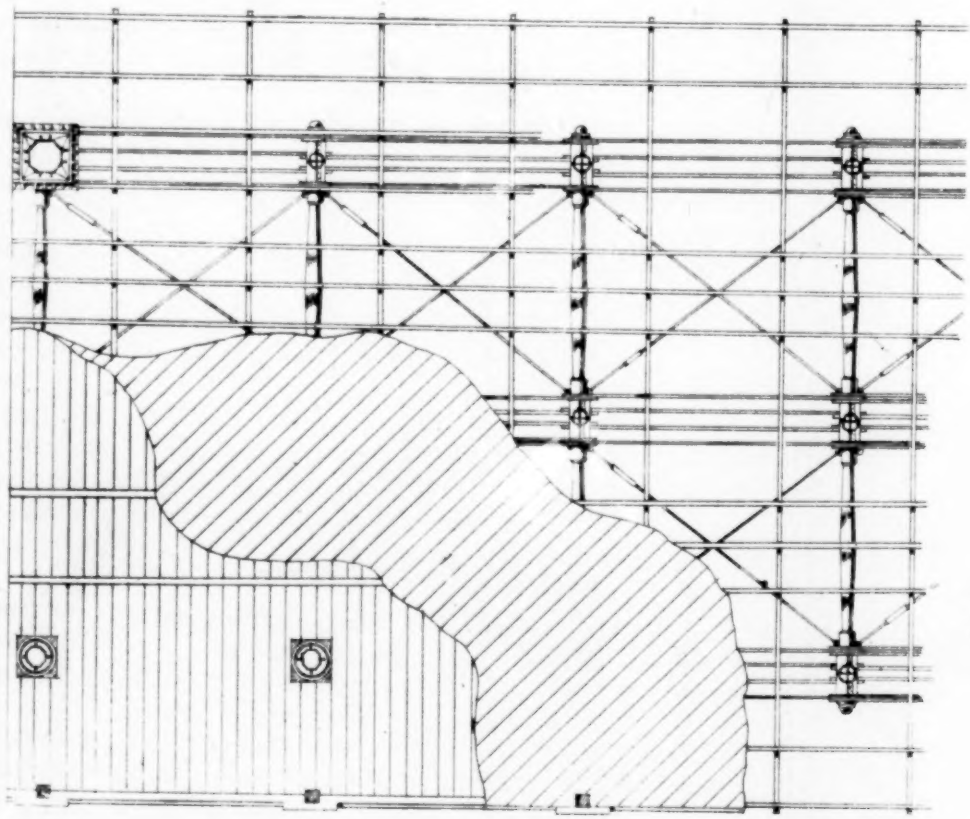
This is a pump that at once dispenses with bored cylinders, piston-rods, and all these complicated appliances; one that can pump sandy water without cutting, and needs no lubrication; one that will allow the whole force of the steam to be exerted in lifting water, and will not consume one-quarter in overcoming the friction of parts as in other pumping engines.

Punched Steel and Iron Tubes.—It is upwards of two years since we first publicly drew attention to the interesting process of making tubes by punching a solid ingot and gradually enlarging it afterwards by punches of successively increasing diameter so as to put the work upon the tube from the inside, instead of, as heretofore, longitudinally. Messrs. Deakin & Johnson's punched tubes have since achieved a great commercial success. Upwards of a quarter of a million have been made; and in many large contracts abroad, especially for the Kensington rifles, no others are used.—*Mec. Mag.*

ITEMS.

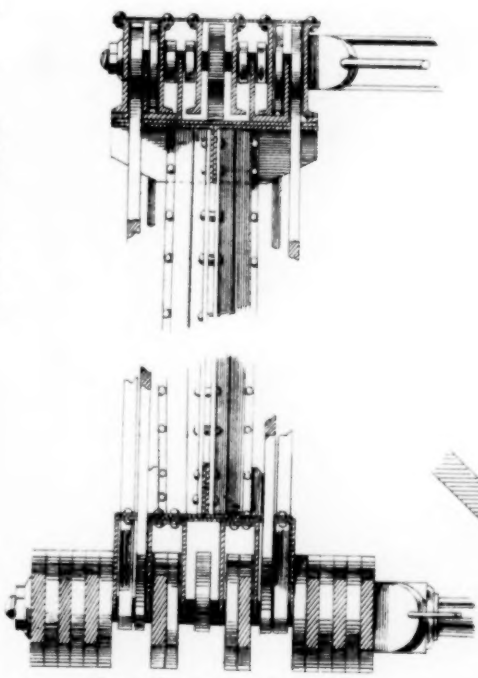
THE NEW FAIRMOUNT BRIDGE

DESIGNED BY J. H. LINVILLE, C. E.



PLAN OF LOWER CHORD AND ROADWAY.

12 FEET TO AN INCH.



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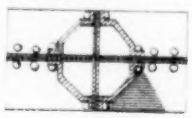

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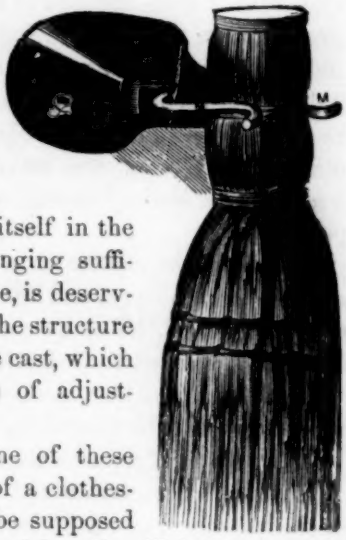
BEN LIPPINCOTT, LITH. 328 WALNUT ST. PHILAD.A PA.

Broom and Tool Holder.—At the last meeting of the *Institute*, there was exhibited a simple and ingenious contrivance for the above purpose, devised by Mr. John G. Powell, and manufactured by Frank S. Judd & Co., of this city. It consists of a soft metal socket, cast upon an ordinary wood screw, with a piece of steel wire so bent and inserted as to clasp and hold securely any object, such as a broom or tool-handle, pressed into its grasp. The manner in which the wire, by a series of bends, is made to fulfil the various offices of securing itself in the socket, grasping the handle, and springing sufficiently to clasp objects of various size, is deserving of high commendation, as also is the structure of the mould in which the sockets are cast, which involves several important features of adjustment.



The accompanying cut shows one of these holders in position, with a handle of a clothes-brush in it. It must not, however, be supposed that a depression in the handle is requisite. It will hold a straight wooden broom-handle just as well.

Proposed Iron Bridge over the Schuylkill River at Fairmount.—By a resolution of Councils, premiums were offered for designs for an iron bridge at Fairmount, and the City Engineer was instructed to advertise for plans and estimates.

The design illustrated in this number of the *Journal*, was submitted by J. H. Linville, C. E., Philadelphia, to whom was awarded the first premium.

The bridge will occupy the site of the present Suspension bridge, the lower roadway accomodating the travel on Callowhill and Haverford streets. The upper roadway will be approached on the west by an iron viaduct on columns, in accordance with designs prepared by the Chief Engineer of the City, carrying the traffic from Bridge Street over the Pennsylvania Railroad tracks. A similar viaduct at the eastern approach will be continued through the Reservoir enclosure, and terminate in Spring Garden Street. The clear span of the bridge is 340 feet, total width 50 feet, and heighth of truss over all, 35 feet. The sidewalks are each 8 feet in width.

ITEMS.

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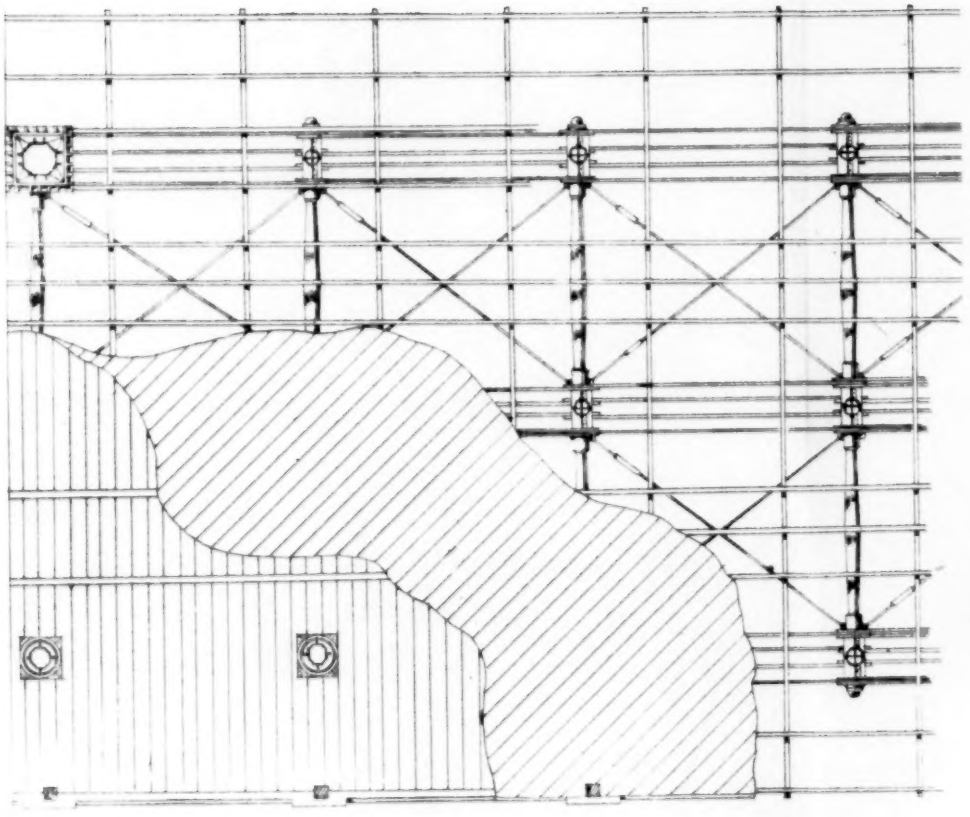

PLAN OF LOWER CHORD AND ROADWAY.

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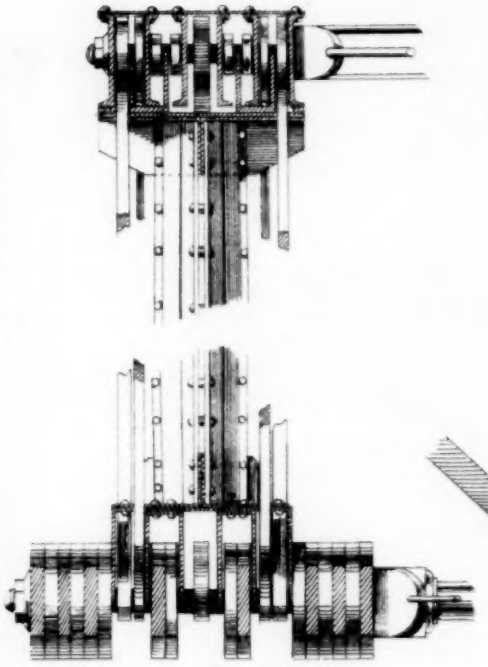

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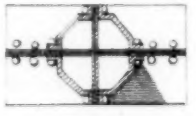

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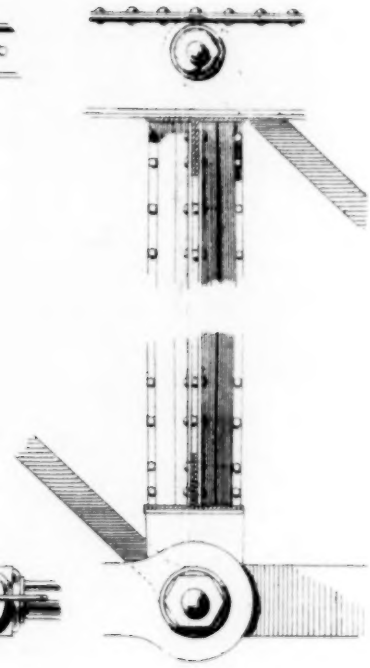

ELEVATION OF POST.

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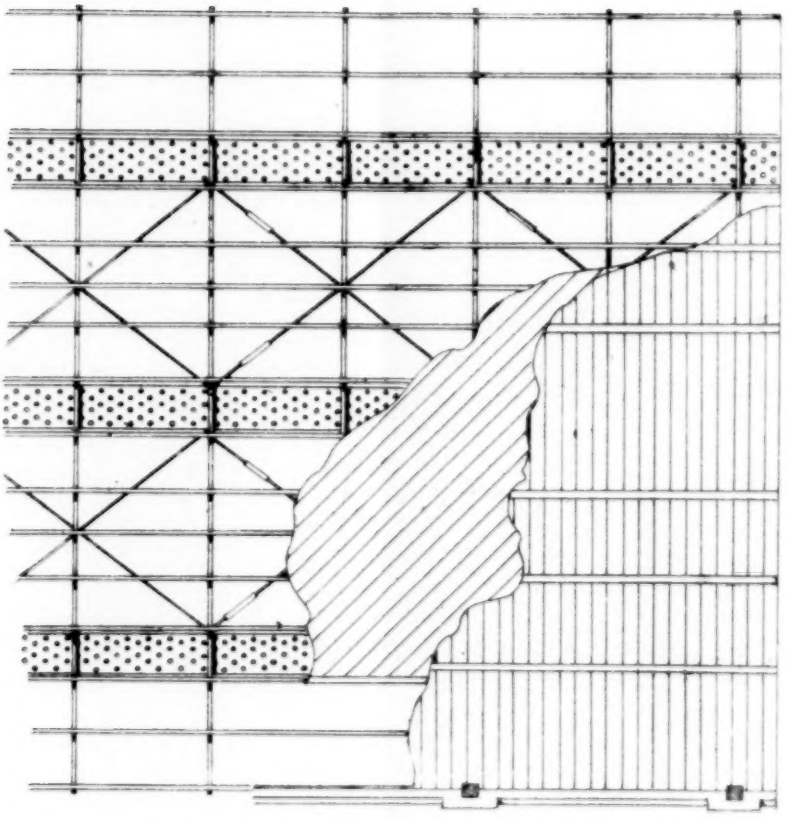

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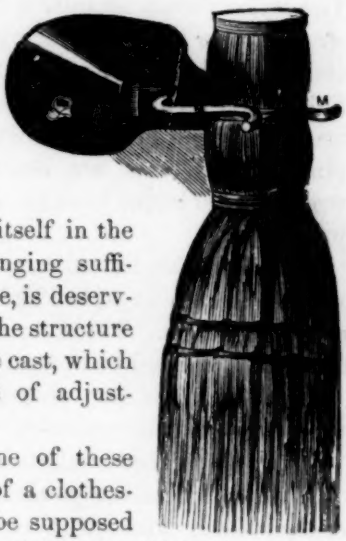

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The variable load assumed is 75 pounds per superficial foot of upper and lower floors, 7,500 pounds per lineal foot of superstructure. With this load uniformly distributed, the several parts of the trusses will be strained to one-sixth of their ultimate strength. The style of truss adopted is known as the Linville & Piper patent wrought iron truss, embracing their patent upper chords of plates and channels, tubular wrought iron posts, and "upset" lower chord links. The vertical and horizontal members of the trusses are connected with the suspension diagonals or links by turned connecting pins. The trusses are stayed laterally, by an arrangement of wrought iron lattice bracing, ornamented by cast iron brackets and pendents.

The footwalks, carried on projecting cantilevers, are protected by suitable iron railings, and finished with ornamental facias, shields and scroll-work. The flooring consists of two courses of 2½-inch oak plank, secured to iron joists.

All parts of the iron work will be accessible for repainting. The wood work will be treated by the Robbins preservative process.

When the bridge, with its long approaches on ornamented iron columns, has been completed, the present dangerous grade-crossing of the railway tracks will be obviated, and Spring Garden Street will have a direct connection with Bridge Street. The entire structure will be of the most substantial and durable character, in style and proportion worthy of a great city, and a pleasing object in the vicinity of the Park.

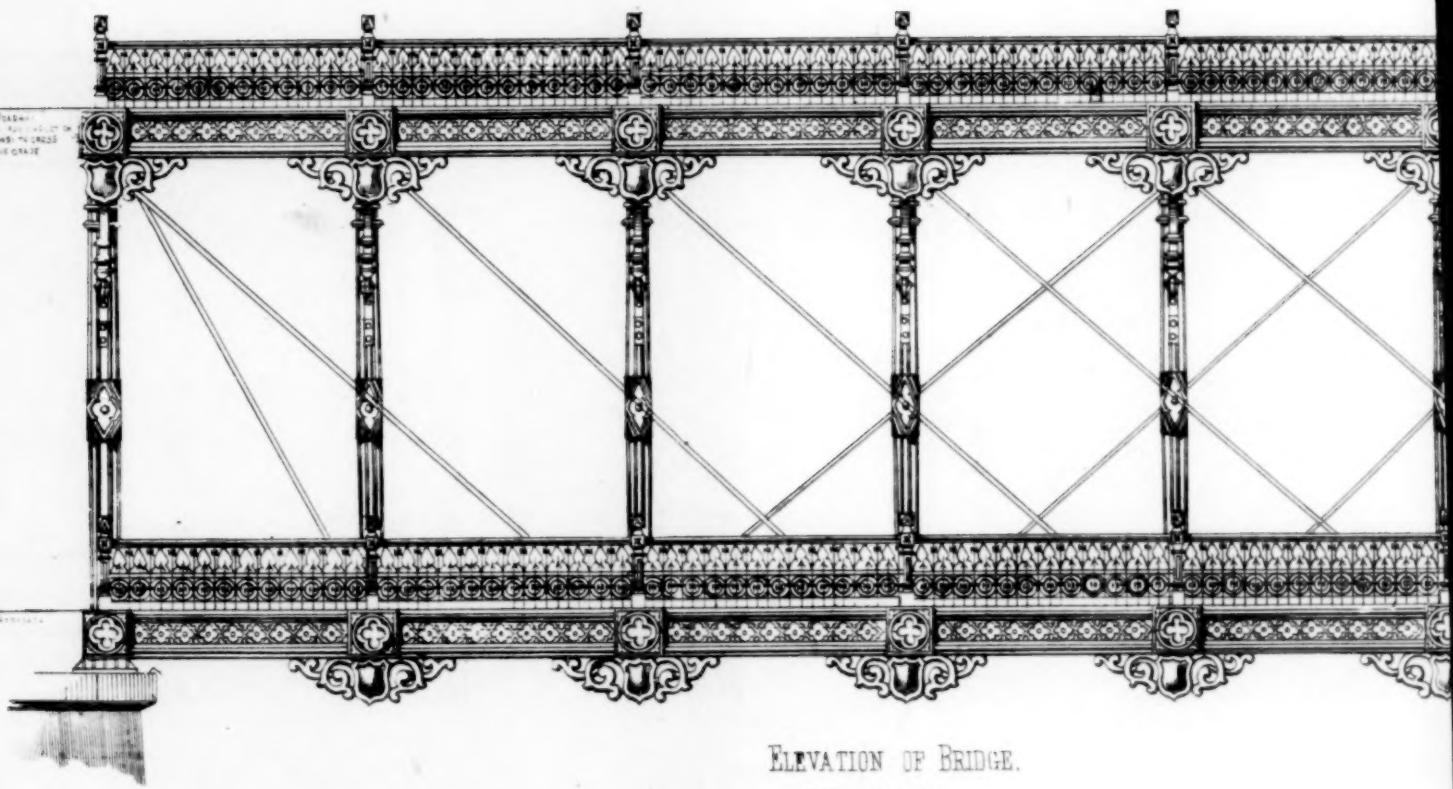
Committee on Plans.—Strickland Kneass, Chief Engineer and Surveyor of Philadelphia; Herman J. Lombaert, 2d Vice-President Pennsylvania Railroad Company; Edward Miller, Civil Engineer, &c.; Solomon W. Roberts, Chief Engineer North Pennsylvania Railroad.

French Atlantic Telegraph Cable is rapidly approaching completion; the whole of the gutta-percha core has been finished at the works at Wharf road, and of the total length of the cable, one section, that from St. Pierre to Boston, has been completed at Mr. W. T. Henley's works, at North Woolwich. The larger section, from Brest to St. Pierre, now making at the Telegraph Construction Company's works at Greenwich, has made such rapid progress that there is no doubt but that it will all be completed to time. The total length of both sections manufactured to May 1st was 3,350 miles, and of this length nearly 2,700 miles had been shipped.

ITEMS.

THE NEW FAIRMOUNT BRID

DESIGNED BY J. H. LINVILLE, C.E.



ELEVATION OF BRIDGE.

12 FEET TO AN INCH.

BEN. LINFOOT, LITH., 328 WALNUT ST. PHILA.A PA.

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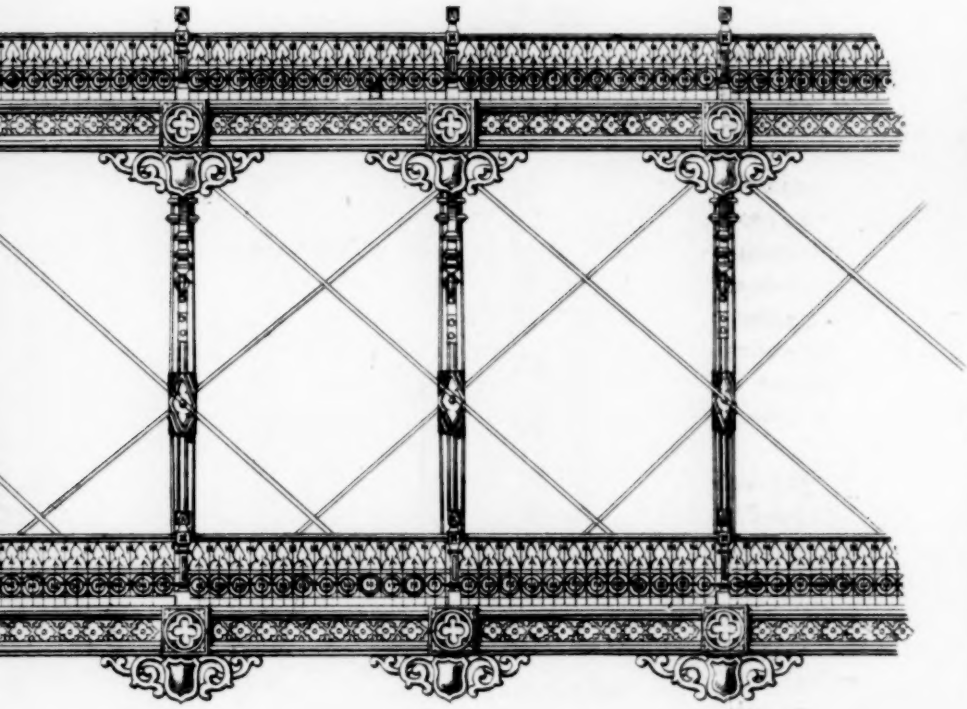
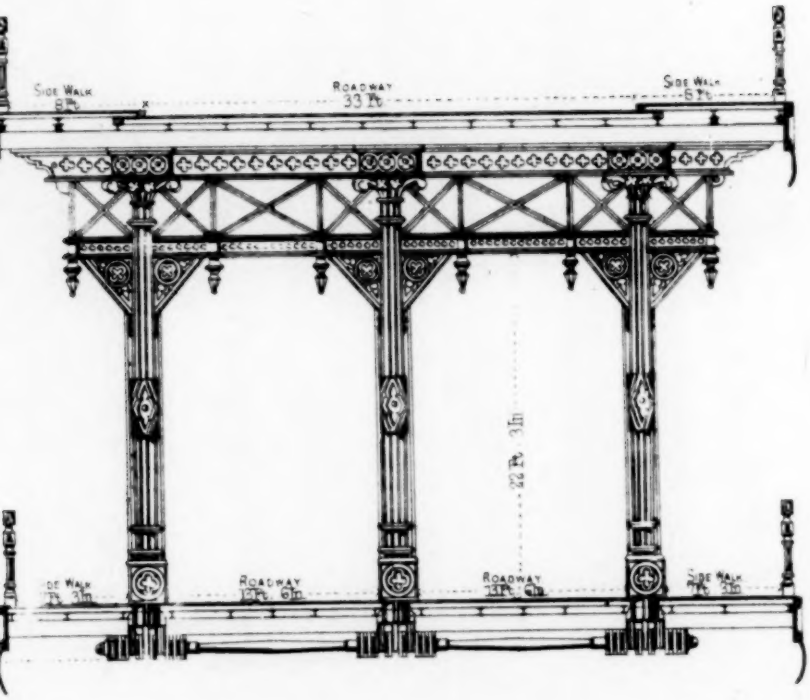


Elevation of Bridge.

12 Feet to an Inch.

Ben. Linfoot, Lith. 308 Walnut St. Phila.a Pa.



CROSS SECTION OF BRIDGE.

12 FEET TO AN INCH.

Three vessels are now receiving cable, the "Great Eastern," with over 2,100 miles of main deep sea cable on board; the "Scanderia," with 450 miles of the United States section; and the "William Cary," with only, as yet, a short length. It is anticipated that the "Great Eastern" will leave Sheerness about the second week in June, but before that time we hope to place before our readers some further interesting details of this truly great enterprise.—*Mech. Mag.*

British Indian Telegraph.—Immediately after the completion of the core for the French Atlantic cable, at the gutta-percha works, the conductor for the British Indian line was commenced to be insulated, and before the "Great Eastern" can leave, the machines at Greenwich will be in full work manufacturing this cable, which will be a few miles longer than the French Atlantic cable. This cable will also be in two sections, the one from Suez to Aden, and the other from Aden to Bombay—a total length of 3,600 miles. The two sections differ from each other in the size of core and in external protection; but on the commencement of the work we shall be able to give some particulars.—*Mech. Mag.*

On the Practical Speed of Electricity through 7,200 miles of Land Wire. By G. Davidson, Esq., Astronomer, United States Coast Survey.

Observations to the above end were made on the night of Feb. 28, 1869, at San Francisco, California, on a loop of wire extending thence to Cambridge, Massachusetts, 3600 miles, and returning to San Francisco; the return signal being received on a chronograph close to that receiving the outgoing signal.

The total interval of time between the records of the two signals amounted to 0·8 of a second; and this may be called the *practical* speed through 7,200 miles of land wire, because that length was cut up in the usual service manner of telegraphic companies, into 11 portions, say, of 650 miles each; these portions being connected by as many relays (or repeaters, as they are called in America,) which send forward on each of these occasions a new electrical current into the next section of the wire; and such new electrical current would travel through its new 650 miles of wire much more quickly than an originel current through the second, third, or any subsequent continued length of 650 miles.

The integral result may, therefore, be looked on as a safe and satisfactory multiplication by 11 of the time occupied by electricity

in both traveling through 650 miles of land wire, and working *one* relay of the kind, whatever that may be, now used in the United States;' the time occupied in effecting such work being apparently 0·07 of a second.

New Paper for New Uses.—We all know to what gigantic proportions the new industry implied in the term "paper collar" has grown, but a new material which has just been introduced bids fair to cast this entirely into the shade, and to exert a very important influence upon the textile manufactures of the world. A material known as felted paper has been devised by M. Pavy, composed of New Zealand flax, jute, mallow, and the ordinary fibres of hemp and cotton, as well as some wool, silk, skin, &c., which are all reduced to "pulp," and treated in the usual way for paper-making.

They produce a material of wonderful pliability and tenacity, about which and its uses our cotemporary, the London *Mechanics' Magazine*, expresses itself as follows:—

"It can be sewn together with as much ease, and makes as strong a seam, as the woven fabrics it is intended to replace. The uses to which this paper can be put are innumerable. We may mention a few of the articles we have seen at the office of Messrs. Roberts and Thorne, 82 Gracechurch street, City. First, petticoats, which no 'girl of the period' could resist. These may be printed exactly like the skirts now so fashionable, or they may be white, and have open-work stamped out in patterns, which scarcely any amount of labor with scissors and needle could imitate. The marvel is that they can be sold retail for sixpence each—little more than the cost of washing a petticoat. We have, next, bed-furniture of imitation cretonnes and chintzes. These are printed with patterns of great beauty, and a set of curtains will only cost five shillings. We have also quilts, which, besides being excellent non-conductors of heat, have a very ornamental appearance. White day-covers for beds are made with embossed patterns, and equally cheap. White table-cloths, stamped with patterns in remarkably good taste, will, we are sure, soon ornament many a dinner-table, and serve to light the fires the day after the party, unless the host be of an economical turn and re-sells them to the paper-maker. But the material is also applied to articles of a more substantial character. Very good imitation leather is formed of it, and furniture-covering, and even shoes may be made. The last can be made impermeable to wet, by the introduction of oils and india-rubber. We have said enough to show

that a material is produced which will probably have considerable influence on some of our staple industries. Paper collars, it may be well supposed, have already had a sensible influence on the linen trade, and the further extensive substitution of paper for woven fabrics must produce still greater changes."

Gold Refining,—a New Process.—A new way of effecting the separation of the silver, in gold refining, has been recently introduced into the Mint at Sydney, Australia.

In order to carry out the operation, a clay crucible is first prepared with borax, by dipping it into a hot saturated solution of the salt, and afterwards thoroughly drying it; all the pores of the crucible being by this means filled. The alloyed metal is melted in the crucible thus prepared; a small quantity of borax being added during the process. A stream of chlorine gas is then caused to pass through the fused mass, and by uniting with the silver forms a chloride of silver, which rises to the top, and remains liquid after the purified gold has been cooled to such a degree as to become solid. After this the molten chloride is poured off, and the silver reduced by the usual chemical process. The previous saturation of the crucible with borax, is found to prevent it from absorbing the chloride, and obviates the loss which would otherwise result from the passage of the liquid chloride through the porous material of the crucible.

Preserving Silver.—The loss of silver which results from the impregnation of our atmosphere with sulphur compounds, especially where gas is burned, is very great. It has been said that many thousands of pounds worth go down our sewers annually in the form of dirt from plate-cleaning, and the loss of one large house on Cornhill, from this source, has been described to us as serious. Silversmith may, then, thank one of their confraternity, Herr Strolberger, of Munich, for a happy thought. He seems to have tried various plans to save his silver, if possible. He covered his goods with a clear white varnish, but found that it soon turned yellow in the window, and spoilt the look of his wares. Then he tried water glass (solution of cilicate of potash), but this did not answer. He tried some other solutions, to no purpose; but at last he hit upon the expedient of doing his goods over with a thin coating of collodion, which he finds to answer perfectly. No more loss of silver, and no longer incessant labor in keeping it clean. The plan he adopted is this:—He first warms the articles to be coated, and then

pays them carefully over with a thinnish collodion diluted with alcohol, using a wide soft brush for the purpose. Generally, he says, it is not advisable to do them over more than once. Silver goods, he tells us, protected in this way, have been exposed in his window more than a year, and are as bright as ever, while others, unprotected, have become perfectly black in a few months.—*Mech. Magazine.*

Silver Plating Solution.—A non-poisonous silver solution—non-poisonous, at all events, in comparison with the cyanide solution, which allows no time for the use of antidotes—though not, possibly, altogether harmless, may be found useful, especially when it can be applied without the use of electricity. The inventor takes one part of nitrate of silver and dissolves it in twenty parts of water. To this solution he adds half a part of sal-ammoniac, and precipitates the silver as chloride, which he again dissolves by the aid of two parts of hyposulphite of soda. Afterwards, he adds to the clear solution two parts of a milk of chalk and water. When used, the mixture is shaken up, a little poured into a saucer, and rubbed over the article to be silvered with a tooth-brush or a linen rag. After rubbing a short time, and rinsing with water, the article, it is said, will be found beautifully silvered.—*Mech. Mag.*

On an Alloy of Iron and Zinc.—It is a well-known fact that Iron is dissolved by molton zinc, but nowhere is any definite alloy of these metals described, nor is it also stated how much Iron is dissolved by Zinc. Dr. Oudemans, Jr., obtained from analysis a piece of metal which had been formed in an iron vessel wherein zinc had been fused for several weeks continually; this metal was found deposited at the bottom of the vessel, and became an impediment to the melting operations in consequence of the relative infusibility of the alloy. In physical aspect this latter was of very much whiter color, and entirely different crystalline structure from zinc; the alloy dissolved very readily and briskly in dilute sulphuric or hydrochloric acid, and was found, on analysis to contain 4·6 per cent of iron. Taking for granted that this alloy is a definite compound of the constituent metals, its formula would be—

$$FeZ_{36} (F=56\,;\ Zn32\ 75).$$

Further Researches on Jargonium, and Ceylon Jargon. By H. C. Sorby, F. R. S., &c.—In my last note I told you that I had found in zircons what appeared to be another elementary substance. I have, since then, made many experiments, and find

that the facts are far more interesting than if they were the effect of a new element. Judging from analogy with all other known substances, no other conclusion could have been formed; but I now find that jargonia exists in two distinct conditions, which have different specific gravities and optical properties. The flamed borax beads give two entirely different spectra, according to the temperature to which the enclosed crystals have been exposed; and there is an analogous difference in the silicates. On taking a pale green jargon, which, naturally, showed a mere faint trace of the absorption bands, and keeping it at a bright red heat for some time, the specific gravity gradually increased from 4.20 to 4.52, and the spectrum then showed all the narrow black absorption bands in as great perfection as my best specimen. This fact is, of course, very interesting; since we can now artificially alter jargons so as to show the bands in the same splendid manner as a few do naturally, and shall thus be able to obtain them without much difficulty, to use as a most excellent natural standard scale, to measure the position of the absorption bands in other spectra.

Eclipses of 1868 and 1869.—In an article upon the eclipse of last year, we noticed (p. 270 of our last volume) De la Rue's calculation of the rotary motion of the great horn. As was there stated, these calculations were based upon certain drawings published in the *London Engineer*. From an article in the Monthly Notices of the Royal Astronomical Society, we just learn that one of these is entirely incorrect, showing an inclination northward where it should have been southward. This, of course, destroys the conclusions as to an axial rotation founded upon the published drawings.

By a curious oversight, the date given by us in the same article (page 273) for the coming eclipse was the same as the one before; it should have been August 7th.

Aqueous Vapor in the Sun.—In a late number of the *Comptes Rendus*, we find a letter from Father Secchi, which contains some statements of so remarkable a character that nothing but such high authority could give them credibility. He tells us, that in examining the light from the vicinity of large sun spots, with a powerfully dispersing spectroscope, in which the incident and refracted beams are nearly parallel, he has frequently met with groups of nebulous bands in the region of red and orange, about 809·5 and 864· of Kirchhoff's scale.

The bands are very distinct from those of the normal spectrum,

and not at all likely to be confused with them. They seem to be made up of many very fine lines, enveloped in a nebulous shade, and appear on the penumbræ of large spots, and on the trains of small ones often found. They are never perceived on the general solar surface. On one occasion, they were observed when the general surface was in field, but it was then found that a light cirrhus cloud was between the observer and the sun. This observation was repeated, and leaves no doubt that these lines are due to the absorbing action of vapor of water.

The Yellow Ray of the Prominences Reversed in the solar spectrum. Father Secchi also announces, that with a spectroscope of nine prisms, he finds a dark band exactly corresponding in position with the yellow ray near D, observed in the spectrum of the prominences and chromosphere. This same band he also found in several stars whose spectra bear a general resemblance to that of the sun. Thus it appeared in Aldebaren, Orion and Polux. Sirius presented a bright region in the corresponding place. In the red stars of the fourth class, *bright* yellow rays may be seen, but it is difficult to fix their position.

Proper Motion of Stars Measured with the Spectroscope.—Father Secchi has repeated and confirmed the observations made by Mr. Huggins on this point (see our last number, page 375,) and has also been able to see the two other bands corresponding with hydrogen, which he finds to be similarly displaced with the F line.

Another Burning Star.—We have, at various times, referred to the curious phenomena attending the outburst of a star in the Northern Crown during May, 1866. (See Vol. LVII., p. 159, and Vol. LII., p. 138.) It now appears that another variable star, R in Gemini, which attained its greatest brightness (5·5) in February last, has been examined by Father Secchi, and finds its spectrum closely analogous to that of the first-mentioned star. It shows a *brilliant* hydrogen ray, and other bright lines, of which the principle ones correspond with the dark bands in a Orionis, between B and D.

The Tower Subway is advancing at the rate of nine feet per day, and the contractor expects to reach the shaft on the Southwark side in less than five months.

Beanes' Process for Bone Black.—On page 398 of our last volume the reference should be to page 423 not 428.

Civil and Mechanical Engineering.

STEAM JACKETTING CYLINDERS OF CORNISH PUMPING ENGINES.

By Henry P. M. Birkinbine, C. E.

It is almost the universal practice in constructing Cornish pumping engines, to surround the steam cylinder with another cylinder, leaving an annular space of about one inch; this space, when the engine is working, is kept filled with steam from the boilers. The steam jacket is considered by most engineers an indispensable part, and it is claimed that with it, an engine can be worked to a higher degree of expansion, and with greater economy of fuel, and that without such an appendage the walls of the cylinder cannot be maintained at an equal temperature and parallel.

Watt, it is said, abandoned the use of the steam jacket for a time, but used it again, believing the efficiency of his engines was improved thereby.

Having had experience in constructing engines of this kind with and without jacketted cylinders, I have been led to question the value of the steam jacket in effecting any economy of fuel, and to doubt whether it does not rather take from the efficiency of an engine. Being an expensive appendage, and, unless carefully handled, liable to get out of repair, it should be abandoned if unnecessary.

The following practical statements may present some facts to sustain the position taken in opposition to high authorities and almost universal practice; remembering that all the power of the engine, whether exerted in the cylinder directly under the piston, or from the jacket through the walls of the cylinder, is drawn from the boilers, it is the utilization of the amount of caloric which is converted into force by the reduction of the steam into water.

The loss of heat in a steam cylinder is—

First.—By radiation from the outside surfaces.

Second.—Heat converted into work by the engine.

Third.—Refrigeration by the condenser.

Outward Radiation from the Cylinder.—This is entirely prevented by the steam jacket, as it is maintained at about the same temperature as the steam in the boilers, which is in excess of that in the cylinder, where expansion is used.

But the outside of the steam jacket will radiate more heat than the steam cylinder, because of its greater circumference, exposing a larger amount of surface, and because it is maintained at a higher temperature. In ordinary practice, the mean temperature in the cylinder is 202°F., and that in the boiler communicating with the steam jacket is 274° F. The careful protection which the cylinders of this class of engines generally receive, prevents radiation from being a source of much loss.

Heat converted into work.—There is no doubt that a higher degree of expansion is possible with a steam-jacketted cylinder, for as the temperature of the steam in the cylinder is lowered, heat is imparted by the steam in the jacket, and the expansion is thus carried to a greater extent. But whatever heat is thus imparted, must be furnished from the boiler. The proposition then becomes this: will the heat, imparted by the steam in the jacket, do more work than if supplied to the steam cylinder directly, either by admitting steam at a higher temperature, or a greater volume of it?

Refrigeration by the condenser.—In single-acting engines, such as the Cornish, the loss is much less than in double-acting engines, as the steam end of the cylinder is never directly connected with the condenser, the steam (usually at about 202° F.) passing through the equilibrium passage into the other end of the cylinder before the exhaust is opened. When the exhaust is open, the inside surface of the cylinder is exposed to the cooling effect of the condenser, and the steam in the jacket is robbed of heat during the entire indoor stroke, or while the steam is doing its work on the opposite side of the piston. This not only wastes power, but throws additional labor on the condensing apparatus.

The objection made that the cylinder will become larger at one end than at the other while in use, because one end connects with the boiler and the other with the condenser, is merely a technical one; for if no heat be conducted from the steam end to the exhaust end by the iron in the cylinder, the difference of temperature is so small, that when represented by the difference in diameter caused by the expansion of the metal, it could not be measured by ordinary means. There is practically none.

The accumulation of water in the cylinder is either the result of loss of heat by the walls of the cylinder, or of excessive expansion or of *priming*. A steam jacket would reconvert any water in the cylinder into steam, if it was in contact with the sides of the cylinder, but as this water would rest upon the piston-head in an ordinary "beam" engine, and upon the lower cylinder head in a "Bull" engine, the heat from the jacket would not act directly upon it, and the process would necessarily be a slow one. Whatever heat is thus imparted, must be taken from the steam in the jacket.

The water can be removed probably as effectually and economically by admitting the steam into the cylinder at a temperature sufficiently above that necessary to perform the work, to absorb all the water. There may have been difficulty in doing this where steam was used at the low pressure of from four to ten pounds, but it can readily be accomplished when the practice is to maintain a pressure of from 30 to 45 pounds.

NEW BLACKFRIARS BRIDGE.

We are sorry to say that now all hopes of completing this magnificent thoroughfare in time for opening by the 24th of this month are at an end. The bridge cannot now be ready for opening before the end of June. This is to be regretted, because the most unceasing efforts have been made to get all forward so as to allow of the inaugural ceremony being held on the 24th inst. There would have been a peculiar fitness in giving up this splendid work to the public on that day, for the 24th of this month is the 50th anniversary of Her Majesty's birth, and it is exactly the 100th anniversary of the date on which old Blackfriars bridge was first opened. Two such coincidences, therefore, seemed to make it imperative that the bridge should be opened on that date, and on none other; and Messrs. Thorn, the contractors, have done their utmost to secure such a desirable result; but it was not to be. Difficulties which no human ingenuity could have foreseen or lessened arose, so that the idea of opening this month was gradually and reluctantly abandoned, and the date is now postponed to some day not yet named, at the end of June or the beginning of July. Even if completed at this date, however, it will be among the quickest built permanent bridges ever stretched across the Thames. The works were begun

in June, 1864,—that is to say, the old bridge was closed at that time. It took eighteen months to remove that ruinous dilapidation, and it was not till the January of 1866 that the present structure was commenced. It will thus, in June, have taken three years and a-half to complete it from first to last. Old Blackfriars was commenced in 1760, and finished, as we have said, in 1769. Vauxhall bridge was begun in 1811, and finished in 1816; Waterloo bridge was also begun in 1811, and finished on the 18th of June, 1817, the second anniversary of Waterloo, after which victory the bridge was called; Southwark bridge took six years to build, Hungerford five years, old Westminster eleven, and new Westminster, from one cause or another, very nearly the same time. London bridge took seven years before it was completed. So that if we get Blackfriars bridge in three years and a-half from its commencement, we shall have no cause to complain of its engineers or of the speed with which the contractors have done their work under them.

As far as regards the structure, the new bridge may be said to be absolutely complete. All the iron ribs of the arches are "bedded" and bolted together. These arches of wrought iron were, of course, built in separate ribs, but were not laid on the stone-work of the piers, and rested entirely on the timber centering, with their ends about three-quarters of an inch from the stone piers, from which they were wedged up. These wedges have now been knocked out, and the arches allowed to settle down into their places on the stone. No bed-plates were used, but between the iron and the stone-work molten lead was run in, and when this had hardened the wedges were knocked away, the iron ribs at once came to their proper bearings, and in no instance was any perceptible deflection observed when the arches were thus left to carry their own weight. The centering is now simply retained in its place for the accommodation of the painters, who are about to paint the whole structure. The iron-work has already had two coats of paint; the last, which is now being given to it, is of a rich bronze green. The outer iron spandrils of the arches are covered at the intersections of the lattice-work with large ornamental bosses, much after the pattern of the well-known heraldic rose. These decorations are to be richly gilt, and the color contrasts which will be afforded by the gilding, the bronze green, the red polished granite, and the white carved stone-work, will make this bridge, as seen from the river, one of the most beau-

tiful works of its kind. Every one of the granite columns have now been fixed. They are the largest ever used in any bridge. Each of them cost more than £800, for they are nearly 24 feet in circumference, and have been polished to the smoothness of an agate surface. Each column stands on a richly-carved pediment of white Portland stone, and each is surmounted by a most massive capital carved in birds, flowers, and sea and river weeds. Four of these capitals have been finished by Mr. Phillips, and their effect is really splendid. The other four are well in hand, and will, it is hoped, be ready when the bridge is opened. Above these capitals will be placed the carved recesses. There are to be four of these on each side of the bridge, so that the somewhat bare and monotonous outline of parapet at Westminster is avoided. Each of these eight recesses are to be 10 feet deep by 13 feet wide. They will be fitted with plain granite benches, but the outer or river side will be carved with quatre-foils deeply cut, but not pierced through. In such a highly ornamental structure as this is to be, it is satisfactory to know that the lamp-posts are to be as artistically treated in form and ornamentation as the rest of the work. These standards are not to be fixed on the parapet, as has always been the case hitherto, but will be in close lines along the curb at each side, so as to throw the greatest amount of light over the broad pavements and over the still broader roadway for the use both of the vehicles and pedestrians. In each of the recesses, however, branched lamps will be placed as beacons to warn the passing river traffic by night where the sharp-edged piers are. About two-fifths of the whole bridge have already been paved with its buckle-plates, and sufficient has been done to form a fair path across the whole bridge, while the two shore arches are quite finished. The abutment on the Surry side has also been quite finished. Nearly all the ornamental parapet work has been delivered at the bridge, but only a few short lengths have been placed in position. It is a very beautiful specimen of Venetian gothic, in its most florid style, and does great credit to the founders. From the inside of the bridge this parapet will appear rather low, being only 3 feet 6 inches in height. From the river, however, it will look bold and sufficiently lofty, as it will stand on the summit of a rich cornice. Next week the work of taking down the scaffolding will be commenced in some parts, and in others the piles around parts of the structure will be drawn. There are, altogether, nearly 6,000 loads of this timber to be removed above and below water, but it is calculated that all may be got away within a

couple of months. Directly the new bridge is opened, the work of pulling down the temporary wooden one alongside it will be proceeded with. This temporary bridge remains as strong as ever. It is, in fact, a temporary bridge only in name, for, with repairs to piles now and then, it would last as long, almost, as old Blackfriars bridge, which, for nearly half the time that it stood, was in a state of chronic dilapidation and decay. The new bridge will cost, altogether, about £320,000, or at the rate of about £4 the superficial foot. At this rate it will be one of the cheapest permanent bridges yet built in London.—*Times.*

A TRACTION ENGINE AT NAMAQUALAND.

THE dullness of this place and Springbok has been greatly and agreeably disturbed by the running of the Cape Copper Mining Company's steam traction engine "Pioneer" along the roads, and great was the astonishment of some of the country people to see an immense (as they called it) fire-wagon traveling without either horses or oxen. It is devoutly to be wished that many more of the same kind of engines may follow, as it is deplorable to see many thousands of tons of copper ore lying upon the company's grounds without the means (unless by the old process) of being transported to a port of shipment. The engine was made by Aveling & Porter, and combines the latest improvements suggested by their great experience in this class of machinery. The trial-trip from this place to Springbok was made on the 19th March, the engine leaving Ookiep early in the afternoon, ascending with ease the steep gradient at the toll-gate, passing through the village to the reduction works, and returning to Ookiep the next day. On the following Tuesday, under the management of Mr. W. Morshead, the company's resident engineer, a more severe trial was made, the engineer, in the presence of the company's superintendent, ascending a steep hill on the Nababeep road, the path being in places very rocky and cut up by water-courses. In returning to Ookiep, an old wagon-road was taken in which a deep "sluit" was met with. This, also, was easily crossed. The engine seemed, in fact, able to make its way almost anywhere that an ox-wagon could be driven, and it will, doubtless, render valuable assistance in the transport of ores and materials.—*The Cape Argus*, April 3, 1869.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LVII., page 382.)

Opinions respecting the Comparative Merits of Gearing and Belting.

"Considerable difference of opinion exists as to the best and most effective principle of conveying motion from the source of power to the machinery of a mill. The Americans prefer leather straps, and large pulleys or riggers.

"In this country, and especially in the manufacturing districts, toothed wheels are almost universally employed.

"In some parts of the South, and in London, straps are extensively used; but in Lancashire and in Yorkshire, where millwork is carried out on a far larger scale, gearing and light shafts at high velocities have the preference.

"Naturally, I am of the opinion that the North is right in this matter, and that consistently, as I was to a great extent the first to introduce that new system of gearing which is now general throughout the country, and to which I have never heard any serious objection, I have been convinced by a long experience that there is less loss of power through the friction of the journals, in the case of geared wheel work, than when straps are employed for the transmission of motive power. Carefully conducted experiments confirm this view, and it is therefore evident which mode of transmission is, as a general rule, to be preferred."

"There are certain cases in which it is more convenient to use straps instead of gearing. With small engines driving saw mills, and some other machinery where the action is irregular, the strap is superior to wheel work, because it lessens the shocks incidental to these descriptions of work. So, also, when the motive power has been conveyed by wheel work and shafting to the various floors of a mill, it is best distributed to the machines by means of straps."

"In some of the American cotton factories, however, there is an immense drum on the first motion, with belts or straps from two to three feet wide, transmitting the power to various lines of shafting, and these in turn through other pulleys and straps, giving motion to the machinery.

"From this description it will be seen that the whole of the mill is driven by straps alone, without the intervention of gearing.

"The advantages of straps are the smoothness and noislessness of the motion. Their disadvantages are cumbrousness, the expense of their renewal, and the necessity for frequent repairs. They are inapplicable in cases where the motion must be transmitted in a constant ratio, because, as the straps wear slack, they tend to slip over the pulleys, and thus lose time. In other cases, as has been observed, this slipping becomes an advantage, as it reduces the shock of sudden strains, and lessens the danger of breaking the machinery.

"Very various materials are employed for straps, the most serviceable of all being leather spliced with thongs of hide or by cement. Gutta percha has been employed with the advantage of dispensing with joints, but it is affected by changes of temperature, and it stretches under great strains. Flat straps are almost universally employed, in consequence of the property they possess of maintaining their position on pulleys, the faces of which are slightly convex.

"Round belts of cat-gut or hemp are sometimes used, running in grooves, which are better made of a triangular than a circular section—so that the belt touches the pulley in two lines only, tangential to the sides of the groove; in this case the friction of the belt is increased in proportion to the decrease of the angle of the groove."

"The strength of straps must be determined by the work they have to transmit. Let a strap transmit a force of n horse-power at a velocity of v feet per minute, then the tension on the driving side of the belt is $\frac{33{,}000\ n}{v}$ lbs., independent of the initial tension producing adhesion between the belt and pulley. For example, let v be 314·16 feet per minute, or the velocity of a 24-inch pulley at 50 revolutions per minute, and let 3 horse-power be transmitted, then $\frac{33{,}000 \times 3}{314{\cdot}16} = 312$ lbs., the strain on the pulley due to the force transmitted."—*Fairbairn, Machinery of Transmission*, H. C. Baird, page 99.

"Throughout New England, until within a few years, it was generally thought by engineers and millwrights, that cotton mills, and woolen mills, and all others, requiring a very considerable power, could not be run effectively without large and ponderous

lines of upright, and horizontal shafts of either cast or wrought iron, and heavy trains of cog-wheels of cast iron, or partly of iron and partly of wood.

"And when large leather belts began to be introduced for the main gear of mills, as a substitute for gear-wheels, it was thought by some of our best Engineers to be an experiment, at the least, of very doubtful result, if not altogether impracticable, and indeed at the present time (1837), notwithstanding all the evident advantages of belts over gear-wheels, many still adhere to the old mode of gearing; and this, doubtless, not so much from a want of discernment and sound judgment, as from a lack of opportunity of comparing and testing the advantages of belts, and the disadvantages of gear-wheels; or, perhaps, they may have formed an erroneous opinion of the utility of using belts from the inspection of some mills, that have been belted on a bad principle, or from belts injudiciously managed."

"Having, from a constant practical experience of both modes of gearing mills, for more than ten years, at Lowell, Saco and other places become fully satisfied of the utility of belting mills, instead of running them with gear-wheels, and that they run much lighter, stiller, and with far less friction, and a proportionately less motive power, with belts than with gear-wheels."

"A cotton mill of dimensions adapted to the convenient operation of 4000 spindles, of cotton machinery, including all the preparation for making yarn, and weaving cloth, ordinarily, required four trains of upright shafts, extending through the height of four stories, the trains usually commencing in the basement story."

"To each train of uprights were attached from two to four pairs of heavy gear-wheels, and in addition to these, in many mills all the counter lines of shafts were geared off at right angles with the horizontal main shaft, which required a very large number of gears and shafts. A mill thus geared is a full load for the power of a moderate sized water-wheel without any machinery, and a great proportion of this unnecessary weight and friction may be saved by the judicious use of belts instead of gears. And besides the disadvantages before named, the trains of gear wheels require the constant extra expense of careful attendance, and of oil or some unctuous matter to lubricate and keep them from heating, friction and abrasion. And again, all the gears must be closely boxed in, and

supplied with tight dripping pans, or the mill-grease will be liable to drop into the work and greatly damage, if not entirely ruin it.

"These are serious inconveniences and evils that may be avoided by substituting belts in place of gear-wheels. The first expense, and the constant repairs will be as little with belts as with gear-wheels; and the risk and hindrance that may be caused by belts is far less; for if a main belt breaks, it is the work of a few minutes only to repair it or replace it with a new one, whereas, the breakage of a single gear-wheel may cause the hindrance of a week, and the almost entire loss of the wheel broken, together with a hundred times the labor and expense in exchanging the broken wheel for the new one, that would be caused in repairing or exchanging the belts. And, again, if it should be found desirable at any time to change the velocity of any part of the mill gear, it is much more easily done, and with far less expense, by varying the size of the pulleys and drums than by changing gear-wheels."

"But to gear a mill wholly with belts, and to do it judiciously, and to the best advantage, doubtless requires more nice calculation, careful judgment, and practical experience, than to do it with gear-wheels for many mills have been so belted as to cause more friction, trouble and expense than would be caused or required in the use of gear-wheels." * * * * * * * *

"In laying out the gear of a mill, it is worth much time and pains to arrange the drums and belts in such a manner that, so far as may be practicable, the stress of one belt upon the journals shall be counteracted by that of another belt in an opposite direction, referring to the stress upon the line of main drums, the counter drums being of minor consequence; but where the main power is to be exerted to throw the stress upon one belt into that of another, is economy in the wear of the whole mill gear, as well as in power, both of which are points of great importance to the manufacturer. This point has not always been observed; for it is sometimes more convenient in arranging the gear and machinery of a mill to place the line of main drums upon one side of the mill instead of in the centre. And the effect of this arrangement is to throw the whole stress of the belts upon one side of the journals of the main drum shafts, which ought ever to be avoided."

* * * * * * * "It is further of great importance that each belt should be of such a length that it will adhere to the drum so much as to prevent it from slipping, and that without the neces-

sity of pulling on the belt so tight as to cramp the drums and wear the bearings. Every belt, to run easy and well, should be so slack, when running, that the slack side should run with a waving, undulating motion, without any tension except on the leading side, and when belts will so run without slipping upon the drums or pulleys they will wear for a great length of time; for although a belt may be heavily loaded, yet, if, at every revolution, it can have an opportunity for relief from its tension so as to contract to its natural texture, it will prevent it from breaking by the stress upon it. But if, otherwise, it be kept strained so tensely as to be constantly strained to its greatest extent on both sides of the drums, it will wear but a short time without cracking at the edges, and will shortly be destroyed."

"Sufficient care is seldom taken to have belts to run free and easy, and it has been one of the greatest errors, more or less prevalent in all cotton or woolen mills, to run the belts so tense as greatly to injurs the belts and rapidly increase the wear of the bearings."

"It has been customary in almost all belted mills to affix heavy cast iron, or wooden binders (tighteners) weighted, to the belts which drive the main mill gear, to prevent them from slipping, and it has been generally thought impracticable to keep them from slipping on the pulleys and drums without binders; but this opinion is wholly erroneous, and without any true foundation, if the belts are properly prepared and pulleys and shafts arranged as mentioned above."

"The method taken to make them run light and slack without slipping has been already given, (see Treatment of Leather for Belts,) and the plan succeeded so well that every manufacturer who uses belts ought to know it."—I. H. B. *Frank. Inst. Jour.*, June, 1837, page 451.

(To be continued.)

Combined Rubber and Steel Belts, by Mr. Louis Sterne, England. In these a band of steel is imbedded in layers of rubber which are attached to it during the process of vulcanizing in so firm a manner that it is found impossible to detach them. It is stated that such belts have been found to work well with heavy machinery.

EXPEDITIOUS RAILWAY MAKING.

THE following despatches to the San Francisco (California) *Evening Bulletin* of April 29th, sent by the correspondents at the eastern end of the Central Pacific Railway, within a few mile of its junction with the Union Pacific Railway, explain themselves. It will be seen that upwards of ten miles of line were laid, ready for the passage of trains, in eleven hours.

"*Third Despatch—Noon.*—A great feat has been accomplished this morning, seven miles of track have been laid by the Central Pacific, and the track layers' party dined in their regular quarters at the end of the new laid track. In one morning 8500 men, 800 horses with teams and all their provender; all the stores of the company and of the Chinese traders, the blacksmith shops, the harness makers' shops, the company's office, the telegraph office, the headquarters of Mr. Stenford, and the abode of Mr. Strobridge and family, and the boarding and sleeping apartments of 500 white men, have moved nine miles as easily as if they had been aboard a large steamship. The dead weight above moved this morning over nine miles of road, seven of which has been built since daylight, includes the ties hauled by teams, without reckoning the rolling stock, fuel or water trains. There are nearly 3000 tons in shop. The camps and commissariat of an army of 10,000 persons have advanced nine miles without the slightest accident into the new country, and no one has suffered the privation of any of the comforts which the best cared for workingmen can enjoy in a mountain town. Not only has this been done, but the army was ready in an hour to move again. How many generals ever see moved such an army in a country 130 miles from fresh water? The rate of laying track has been one mile an hour—the first time it has ever been attempted, and it may be the last, for it is not probable that such an army will be organized again.

"*Fourth Despatch. End of Central Pacific Track April* 28, *P. M.*—The greatest work in track-laying ever accomplished or conceived by railroad men has been successfully achieved to-day by the Central Pacific Company. Ten miles and 58 feet of railroad (grading excepted) has been made between daylight and sundown. Some two or three miles of this had been hauled out by teams yesterday on the advance, but all the iron rails, fish bars, bolts and spikes were

carried out to-day, and the most part of it was brought a number of miles from the rear, as the station this morning was two miles behind the foremost rails. The ties for over 7 miles had to be hauled by two-horse teams from 5 miles, where they were first laid, to over 12 miles where they were last laid, and this over a rapidly rising grade and mountain road. As there are about 2400 ties to a mile, and they are from 80 to 90 lbs. in weight, it makes 1,244,000 lbs., without the 16,800 ties teamed and laid. This only represents part of the work done by teams, as all the blacksmith, wheelwright and other workshops went by the wagon road. One length of such camp wagons by count numbered 25, and, spun out in a thin line, looked like one of the large emigrant trains of former days. The iron moved by the construction train was 1000 tons, and the whole of that has been laid, spiked, fished and bolted in 11 working hours, and the road to the end of the track, though needing a little revision in places, is fit for travel and in fair condition. The difficulty of doing this work was increased by the necessity of carrying a large water-tank car with every one of the six engines employed. It was still increased by the number of curves, which required the bending of the rails in many places for several lengths, which had to be done on the ground as the curves right or left required. The feat of laying over 7 miles in one stretch was once done by the Union Pacific, but they worked from four in the morning until after midnight, Therefore it could not be considered an honest day's work. The Central men would have laid 14 miles, and finished their portion of the great Pacific Road to-night, had the grading been completed. As it was, the men were anxious to lay 12 miles, but there were not ties enough within 50 miles of the spot."

ON NEW EXPLOSIVE POWDERS.

By M. Designolle.

(ABSTRACT.)

Many improvements having lately been made in the art of war, and particularly in the adoption of breech-loading arms, the want has been felt of new powders to meet the requirements of the present artillery. This want has been supplied by M. Designolle, who

has invented a new system of powders of which carbazotate or picrate of potash is the base. These powders are of four kinds—viz., a musket powder, gunpowder for short bore cannons, slow gunpowder for cannons with long bores, and an explosive powder for torpedoes and projectiles destined for the undermining of fortifications. The principal advantages of these new powders are the following:—Increase of balistic power without increase of explosive power; the base remaining the same, possibility of regulating and varying the effects between the limits of one to ten; also of regulating, at will, the rapidity of combustion of this powder, and of increasing the balistic power without changing the mode of manufacture. Other advantages are—regularity in the manner of action; suppression of sulphur, and consequently of the vapors of sulphide of potassium and sulphuretted hydrogen; absence of action on metals and almost entire suppression of smoke. Into the explosive powders only two components enter—picrate of potash and nitrate of potash; the musket and gunpowders contain carbon in addition to the above-named ingredients. To prepare these powders, the ingredients are beaten from three to six hours with a proportion of water varying from 6 to 14 per cent., according to the nature of the mixture; the powder is condensed by means of the hydraulic press, with a pressure of from 30,000 to 100,000 kilos., graining of the powder, and pressing and drying it according to the methods employed for the black powder. In order to increase the balistic power, the relative proportion of picrate of potash in the mixture must be increased. For musket powder it has been proved that not more than 20 per cent. of picrate of potash is required, while for gunpowders its proportion varies from 8 to 15 per cent. This component (picrate of potash) is of a beautiful golden yellow color, and crystallizes in prismatic needles possessing a brilliant reflection; it is insoluble in alcohol, but soluble in about 260 parts of water at 15 or 14 parts of boiling water. Heated with care it becomes orange red at a temperature of 300°, but, on cooling, it assumes its original color. Heated to 310°, it detonates with violence. The researches of M. John Casthellaz on the action of nitric acid on phenic acid improved the method of manufacturing picric acid, and produced chemically pure picrate of potash at such a reasonable price that the new powders are not more expensive than ordinary black powder.

MM. Designolle and Casthellaz give the following proportions for preparing deflagrating mixtures with colored flames:

Golden fire	Picrate of ammonia.	50
	Picrate of iron.....	50
Green fire	Picrate of ammonia.	48
	Nitrate of barytes....	52
Red fire	Picrate of ammonia.	54
	Nitrate of strontian.	46

—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale.*

A STEAM PLOW.

THE steam plow and accompanying apparatus, imported by Col. Wm. E. Patterson from Leeds, England, was put in operation on Tuesday last, on the recent purchase of that gentleman at Atsion, New Jersey.

Colonel Patterson's large tract of land in that locality is to be devoted to the culture of sugar beet. As the soil is a sandy loam, closely akin to that in which the French have been so successful in sugar beet culture, Colonel Patterson sees no reason why a profit cannot be realized in this country in the same direction.

The test of this steam plow was made in the presence of a considerable number of people, including General Capron, of the United States Agricultural Bureau at Washington. This gentleman, having beaten his sword into a ploughshare, has from the first taken active interest in the subject of relieving horses from this arduous and exhausting labor. Through his intervention the apparatus, which cost $13,000, was admitted free of duty, and at its successful operation on Tuesday no one evinced a higher degree of satisfaction.

The machinery is by no means complicated. At opposite sides of the space to be plowed are two steam engines upon wheels. On the trial on Tuesday they stood three hundred yards apart. The plow has six shares. It is a distinct piece of mechanism, and is fastened to a steel wire cable extending between the two locomotives across the ground to be turned over. It is literally a shuttle cock between two steam battledores. It moves at the speed of a hundred yards a minute, turning six furrows a foot each in width, and eight inches in depth. Its average work, therefore, is twenty acres per day. The locomotives are snug machines, capable of

being applied to many useful purposes independent of duty as steam plowers.

A man rides on the plow as it crosses the soil. General Capron essayed a trip or two, guiding the machine like an expert upon a velocipede. One of the experts who mounted it just after him had less good fortune. One of the diggers struck a buried boulder. When an irresistable body in motion strikes against an immovable one a rumpus must be the result. In this case the man upon the machine was slung high into the air. The concussion broke off two of the teeth of the digger, but as a new one immediately replaced it, the accident was a matter of little consequence.

Of this large track of ground much is virgin soil. The trunks of many cedars, showing slight evidences of decay, were brought to light by the steam plowshares. These were crunched up by them as if they were mere touchwood. The soil above them is largely made up of decayed vegetable matter, and in the opinion of all who were present, the sugar beet will produce in it enormous crops. A digging machine accompanies the plow, intended for use in soils where roots and stones are obstacles to the course of the plowshare. This is a wonderful apparatus. It so triturates the stiffest soil that a yankee might put it into bladders and vend it as a substitute for snuff.

The trial was witnessed, among others, by General Fitz John Porter, Wm. B. Tatham, General Robert Patterson and family, Judge Carpenter, of New Jersey; Mr. Landreth, of Philadelphia; T. C. Peters, of New York; B. M. Rhodes, of Baltimore; Mr. Harry McCall, and a strong delegation of gentlemen from various parts of the surrounding country.

The machinery is the work of Towles & Co., of Leeds, England. To work it costs extremely little. Anything answers as fuel, and at the rate of twenty acres a day a large estate is soon put under cultivation. The locomotives are then ready for ordinary duty as steam engines, either to grind or thresh, sew or mash.

Improvement in the Holtz Machine.—Mr. Joseph Cresson, of this city, has found that the pieces of paper usually attached as inductors, may be replaced with great advantage by figures of like shape painted on the glass with white lead. This never curls up at the edge and is more easily insulated.

THE TOWER SUBWAY.

AMONST the many great improvements now going on in London to relieve the over-crowded state of traffic, and for opening up new means of communication, the Tower Subway is one which deserves especial notice, as forming an easy and safe connection between the two densely-populated districts situated north and south of the Thames, between London Bridge and the Thames Tunnel. This work is now in course of construction under the bed of the river, from Tower Hill to Tooley Street, and consists of a tunnel less than a quarter of a mile in length, access being gained to it by a shaft at each end. The depth of these shafts will be 52 feet and 60 feet respectively, in which it is proposed to have plumb lifts for the transit of passengers, parcels, etc., to and from the subway, through which an omnibus running on steel rails is propelled, both being worked by steam power. In driving the subway, which will be about 22 feet below the bed of the river, a wrought iron shield will be employed overlapping the tunnel, provided with doors in the front, through which workmen can drive the heading, but which can be immediately closed on any appearance of water, and so render all water-tight; this shield will be propelled by powerful screws, and as it progresses, the tunnel segments will be inserted. The whole of the work is under the superintendence of Mr. Peter W. Barlow, Jr., C. E., the engineer; the contractor being Mr. J. H. Greathead, under whose superintendence the shafts are now being sunk by Mr. Thomas Tilley, of 2 Bond Court, Walbrook, London, the well known artesian well engineer. The castings for these shafts and the tunnel, which are all made in segmental rings firmly bolted together, as also the manufacture of the shield, are entrusted to the firm of Messrs. Bells, Goodman & Co., of the Walker Engine Works and Foundry, Newcastle-upon-Tyne, and 25 Walbrook, London. The Tower Subway was commenced on the 16th of last February, and as the shaft for the Middlesex side is already sunk to the depth of 60 feet, and the remainder of the work well advanced, we are informed that it is expected to be opened to the public before the commencement of the year 1870.—*Mec. Mag.*

Mechanics, Physics, and Chemistry.

ON THE BLUE COLOR OF THE SKY, THE POLARIZATION OF SKY-LIGHT, AND POLARIZATION OF LIGHT BY CLOUDY MATTER GENERALLY.

By John Tyndall, L.L.D., F.R.S.

Since the communication of my brief abstract "On a new Series of Chemical Reactions produced by Light," the experiments upon this subject have been continued, and the number of the substances thus acted on considerably augmented. New relations have also been established between *mixed vapors* when subjected to the action of light.

I now beg to draw the attention of the Royal Society to two questions glanced at incidentally in the abstract referred to—the blue color of the sky, and the polarization of skylight. Reserving the historic treatment of the subject for a more fitting occasion, I would merely mention now that these questions constitute, in the opinion of our most eminent authorities, the two great standing enigmas of meteorology. Indeed it was the interest manifested in them by Sir John Herschel, in a letter of singular speculative power, that caused me to enter upon the consideration of these questions so soon.

The apparatus with which I work consists, as already stated to the Society, of a glass tube about a yard in length, and from two and a half to three inches internal diameter. The vapor to be examined is introduced into this tube in the manner described in my last abstract, and upon it the condensed beam of the electric lamp is permitted to act until the neutrality or the activity of the substance has been declared.

It has hitherto been my aim to render the chemical action of light upon vapors *visible*. For this purpose substances have been chosen, *one* at least of whose products of decomposition under light shall have a boiling-point so high that as soon as the substance is formed it shall be *precipitated*. By graduating the quantity of the vapor, this precipitation may be rendered of any degree of fineness, forming particles distinguishable by the naked eye, or particles which

are probably far beyond the reach of our highest microscopic powers.

I have no reason to doubt that particles may be thus obtained whose diameters constitute but a very small fraction of the length of a wave of violet light.

In all cases when the vapors of the liquids employed are sufficiently attenuated, no matter what the liquid may be, the visible action commences with the formation of a *blue cloud.* I would guard myself at the outset against all misconception as to the use of this term. The blue cloud to which I here refer is totally invisible in ordinary daylight. To be seen, it requires to be surrounded by darkness, *it only* being illuminated by a powerful beam of light. This blue cloud differs in many important particulars from the finest ordinary clouds, and might justly have assigned to it an intermediate position between these clouds and true cloudless vapor.

With this explanation, the term "cloud," or "incipient cloud," as I propose to employ it, cannot, I think, be misunderstood.

I had been endeavoring to decompose carbonic acid gas by light. A faint bluish cloud, due it may be, or it may not be, to the residue of some vapor previously employed, was formed in the experimental tube. On looking across this cloud through a Nicol's prism, the line of vision being horizontal, it was found that when the short diagonal of the prism was vertical, the quantity of light reaching the eye was greater than when the long diagonal was vertical.

When a plate of tourmaline was held between the eye and the bluish cloud, the quantity of light reaching the eye when the axis of the prism was perpendicular to the axis of the illuminating beam, was greater than when the axes of the crystal and of the beam were parallel to each other.

This was the result all round the experimental tube. Causing the crystal of tourmaline to revolve round the tube, with its axis perpendicular to the illuminating beam, the quantity of light that reached the eye was in all its positions a maximum. When the crystallographic axis was parallel to the axis of the beam, the quantity of light transmitted by the crystal was a minimum.

From the illuminated bluish cloud, therefore, polarized light was discharged, the direction of maximum polarization being at right angles to the illuminating beam; the *plane of vibration* of the

polarized light, moreover, was that to which the beam was perpendicular.*

Thin plates of selenite or of quartz, placed between the Nicol and the bluish cloud, displayed the colors of polarized light, these colors being most vivid when the line of vision was at right angles to the experimental tube. The plate of selenite usually employed was a circle, thinnest at the centre, and augmenting uniformly in thickness from the centre outwards. When placed in its proper position between the Nicol and the cloud, it exhibited a system of splendidly colored rings.

The cloud here referred to was the first operated upon in the manner described. It may, however, be greatly improved upon by the choice of proper substances, and by the application in proper quantities of the substances chosen. Benzol, bisulphide of carbon, nitrite of amyl, nitrite of butyl, iodide of allyl, iodide of isopropyl, and many other substances may be employed. I will take the nitrite of butyl as illustrative of the means adopted to secure the best result with reference to the present question.

And here it may be mentioned that a vapor, which when alone, or mixed with air in the experimental tube, resists the action of light, or shows but a feeble result of this action, may, by placing it in proximity with another gas or vapor, be caused to exhibit under light vigorous, if not violent, action. The case is similar to that of carbonic acid gas, which diffused in the atmosphere resists the decomposing action of solar light, but when placed in contiguity with the chlorophyl in the leaves of plants, has its molecules shaken asunder.

Dry air was permitted to bubble through the liquid nitrite of butyl until the experimental tube, which had been previously exhausted, was filled with the mixed air and vapor. The visible action of light upon the mixture after fifteen minutes' exposure was slight. The tube was afterwards filled with half an atmosphere of the mixed air and vapor, and another half atmosphere of air which had been permitted to bubble through fresh commercial hydrochloric acid. On sending the beam through this mixture, the action paused barely sufficiently long to show that at the moment of commencement the

* I assume here that the plane of vibration is perpendicular to the plane of polarization. This is still an undecided point; but the probabilities are so much in its favor, and it is in my opinion so much preferable to have a physical image on which the mind can rest, that I do not hesitate to employ the phraseology in the text. Even should the assumption prove to be incorrect, no harm will be done by the provisional use of it.

tube was optically empty. But the pause amounted only to a small fraction of a second, a dense cloud being immediately precipitated upon the beam which traversed the mixture.

This cloud began *blue*, but the advance to whiteness was so rapid as almost to justify the application of the term instantaneous. The dense cloud, looked at perpendicularly to its axis, showed scarcely any signs of polarization. Looked at obliquely, the polarization was strong.

The experimental tube being again cleansed and exhausted, the mixed air and nitrite of butyl vapor was permitted to enter it until the associated mercury column was depressed one-tenth of an inch. In other words, the air and vapor, united, exercised a pressure not exceeding $\frac{1}{300}$th of an atmosphere. Air passed through a solution of hydrochloric acid was then added till the mercury column was depressed three inches. The condensed beam of the electric light passed for some time in darkness through this mixture. There was absolutely nothing within the tube competent to scatter the light. Soon, however, a superbly blue cloud was formed along the track of the beam, and it continued blue sufficiently long to permit of its thorough examination. The light discharged from the cloud at right angles to its own length was *perfectly* polarized. By degrees the cloud became of whitish blue, and for a time the selenite colors obtained by looking at it normally were exceedingly brilliant. The direction of maximum polarization was distinctly at right angles to the illuminating beam. This continued to be the case so long as the cloud maintained a decided blue color, and even for some time after the pure blue had changed to whitish blue. But as the light continued to act the cloud became coarser and whiter, particularly at its centre, where it at length ceased to discharge polarized light in the direction of the perpendicular, while it continued to do so at both its ends.

But the cloud which had thus ceased to polarize the light emitted normally, showed vivid selenite colors when looked at *obliquely*. The direction of maximum polarization changed with the texture of the cloud. This point shall receive further illustration subsequently.

A blue, equally rich and more durable, was obtained by employing the nitrite of butyl vapor in a still more attenuated condition. Now the instance here cited is *representative*. In all cases, and with all substances, the cloud formed at the commencement, when the precipitated particles are sufficiently fine, is *blue*, and it can be made

to display a color rivalling that of the purest Italian sky. In all cases, moreover, this fine blue cloud polarizes *perfectly* the beam which illuminates it, the direction of polarization enclosing an angle of 90° with the axis of the illuminating beam.

It is exceedingly interesting to observe both the perfection and the decay of this polarization. For ten or fifteen minutes after its first appearance, the light from a vividly illuminated incipient cloud, looked at horizontally, is absolutely quenched by a Nicol's prism with its longer diagonal vertical. But as the sky-blue is gradually rendered impure by the introduction of particles of too large a size, in other words, as real clouds begin to be formed, the polarization begins to deteriorate, a portion of the light passing through the prism in all its positions. It is worthy of note that for some time after the cessation of perfect polarization the *residual* light which passes, when the Nicol is in its position of minimum transmission, is of a gorgeous blue, the whiter light of the cloud being extinguished.* When the cloud texture has become sufficiently coarse to approximate to that of ordinary clouds, the rotation of the Nicol ceases to have any sensible effect on the quality of the light discharged normally.

The perfection of the polarization in a direction perpendicular to the illuminating beam is also illustrated by the following experiment. A Nicol's prism large enough to embrace the entire beam of the electric lamp was placed between the lamp and the experimental tube. A few bubbles of air, carried through the liquid nitrite of butyl, were introduced into the tube, and they were followed by about three inches (measured by the mercurial gauge) of air which had been passed through aqueous hydrochloric acid. Sending the polarized beam through the tube, I placed myself in front of it, my eye being on a level with its axis, my assistant Mr. Cottrell occupying a similar position behind the tube. The short diagonal of the large Nicol was in the first instance vertical, the plane of vibration of the emergent beam being therefore also vertical. As the light continued to act, a superb blue cloud, visible to both my assistant and myself, was slowly formed. But this cloud, so deep and rich when looked at from the positions mentioned, *utterly disappeared when looked at vertically downwards, or vertically upwards.* Reflection from the cloud was not possible in these

* This seems to prove that particles too large to polarize the blue, polarize perfectly light of lower refrangibility.

directions. When the large Nicol was slowly turned round its axis, the eye of the observer being on the level of the beam, and the line of vision perpendicular to it, entire extinction of the light emitted horizontally occurred where the longer diagonal of the large Nicol was vertical. But now a vivid blue cloud was seen when looked at downwards or upwards. This truly fine experiment was first definitely suggested by a remark addressed to me in a letter by Prof. Stokes.

Now, as regards the polarization of skylight, the greatest stumbling block has hitherto been that, in accordance with the law of Brewster, which makes the index of refraction the tangent of the polarizing angle, the reflection which produces perfect polarization would require to be made *in* air *upon* air and indeed this led many of our most eminent men, Brewster himself among the number, to entertain the idea of *molecular reflection*. I have, however, operated upon substances of widely different refractive indices, and therefore of very different polarizing angles as ordinarily defined, but the polarization of the beam by the incipient cloud has thus far proved itself to be *absolutely independent of the polarizing angle*. The law of Brewster does not apply to matter in this condition, and it rests with the undulatory theory to explain why. Whenever the precipitated particles are sufficiently fine, no matter what the substance forming the particles may be, the direction of maximum polarization is at right angles to the illuminating beam, the polarizing angle for matter in this condition being invariably 45°. This I consider to be a point of capital importance with reference to the present question.*

That *water-particles*, if they could be obtained in this exceedingly fine state of division, would produce the same effects, does not admit of reasonable doubt. And that they must exist in this condition in the higher regions of the atmosphere is, I think, certain. At all

* The difficulty referred to above is thus expressed by Sir John Herschel:—"The cause of the polarization is evidently a reflection of the sun's light upon *something*. The question is on what? Were the angle of maximum polarization 76°, we should look to water or ice as the reflecting body, however inconceivable the existence in a cloudless atmosphere, and a hot summer's day of unevaporated molecules (particles?) of water. But though we were once of this opinion, careful observation has satisfied us that 90°, or thereabouts, is a correct angle, and that therefore whatever be the body on which the light has been reflected, *if polarized by a single reflection*, the polarizing angle must be 45°, and the index of refraction, which is the tangent of that angle, unity; in other words, the reflection would require to be made *in* air *upon* air!" ('Meteorology,' par. 233.)

events, no other assumption than this is necessary to completely account for the firmamental blue and the polarization of the sky.*

Suppose our atmosphere surrounded by an envelope impervious to light, but with an aperture on the sunward side through which a parallel beam of solar light could enter and traverse the atmosphere. Surrounded on all sides by air not directly illuminated, the track of such a beam through the air would resemble that of the parallel beam of the electric lamp through an incipient cloud. The sunbeam would be *blue*, and it would discharge laterally light in precisely the same condition as that discharged by the incipient cloud. In fact the azure revealed by such a beam would be to all intents and purposes that which I have called a "blue cloud."†

(To be continued.)

THE GREAT INDUCTION COIL.

One of the greatest scientific wonders, even in this wonder-producing age, is unquestionably the great induction coil—or inductorium, as the German physicists term it—at the Polytechnic Institution It is an instrument of remarkable power and capacity, and possesses the highest scientific interest.

The machine consists of an ebonite barrel, 9 feet 10 inches in length, supported at each end on two ebonite pillars. The barrel was made at the Silvertown Works, and is the largest ever turned out there. It contains the compound coil, and of itself weighs 477 pounds, the whole machine weighing 15 cwt.

* Any particles, if small enough, will produce both the color and the polarization of the sky. But is the existence of small water-particles on a hot summer's day *in the higher regions of our atmosphere* inconceivable? It is to be remembered that the oxygen and nitrogen of the air behave as a vacuum to radiant heat, the exceedingly attenuated vapor of the higher atmosphere being therefore in practical contact with the cold of space.

† The opinion of Sir John Herschel, connecting the polarization and the blue color of the sky is verified by the foregoing results. "The more the subject (the polarization of skylight) is considered," writes the eminent philosopher, "the more it will be found beset with difficulties, and its explanation when arrived at will probably be found to carry with it that of the blue color of the sky itself, and of the great quantity of light it actually does send down to us." "We may observe, too," he adds, "that it is only where the purity of the sky is most absolute that the polarization is developed in its highest degree, and that where there is the slightest perceptible tendency to cirrus it is materially impaired." This applies word for word to the "incipient clouds."

The primary wire is of copper of the highest conductivity 0·0925 inches diameter (B. W. G. No. 13), and 3,770 yards in length; the number of revolutions of the primary wire round the soft iron core is 6,000, its arrangement being three, six, and twelve strands. The total resistance of the primary coil is 2·201400 British Association units; and the resistances of the primary conductors are respectively, for the three strands, 0·733800; for the six, 0·366945; for the twelve, 0·1834725 B. A. units. The soft iron core is composed of straight wires of very soft iron, each wire being 5 feet in length, and 0·0625 inches in diameter. The diameter of the bundle of core wires is four inches, and their weight 123 pounds. The secondary wire is 150 miles in length, 0·015 inch diameter, (B. W. G. No. 29), and is covered with silk. The total weight of the wire is 606 pounds, and its electrical resistance 33,560 B. A. units. The secondary coil is 4 feet 2 inches long, and the insulation is calculated for safety at 95 per cent. beyond absolute requirement. The secondary wire is insulated from the primary by an ebonite tube 8 feet in length, and $\frac{1}{2}$ inch in thickness. The condenser is made of sheets of varnished paper and tinfoil, arranged in six parts, each containing 125 feet of surface, or a total of 750 feet.

The machine was originally tried with a contact breaker detached from the great coil, and having an independent electro-magnet; this worked well up to ten Bunsen cells with the great inductorium, but when the battery was increased to thirty or forty cells it became unmanageable. A Ruhmkorff break, with mercury and alcohol above it, was substituted, which saved the points, but the spirit was now and then violently ejected and set on fire. Professor Pepper then proposed a modification, which has proved successful, remaining in perfect working order during a series of experiments extending over eight hours. The commutator regulating the admission of the battery current is provided with a locking apparatus, and the whole coil is most carefully and effectually insulated from the floor and surrounding apparatus, as are also the separate portions of the apparatus from each other. The battery power is at present supplied by forty Bunsen cells, each containing a pint of nitric acid. It is, however, intended to substitute for this, a Grove's battery of the largest size ever made, and which is in course of construction. It will consist of pipe-clay cells 2 feet square upon the sides, and 3 inches wide, with walls an eighth of an inch thick.

In working the great induction coil, the sparks obtained from it

with five Bunsen cells, are 12 inches in length; ten cells give sparks 14 inches in length; fifteen cells give 17½-inch sparks; twenty cells give 21-inch sparks; twenty-five cells give 23-inch sparks; thirty cells give 23½-inch sparks; thirty-five cells give 26-inch sparks; forty cells give 27½-inch sparks; and with fifty cells, sparks from 28-inch to 29-inch in length were obtained. After eight hours working, the coil gave, with fifty cells, a spark 25½ inches in length. It was also found that of the proportions of the condenser used, one-half gave the longest spark. The spark is not such as is generally produced under similar circumstances, but is a thick wire of light, surrounded by a wide waving flame 2 inches or three inches thick, and which can be blown aside from the spark. The spectroscope gives a perfectly continuous spectrum, like the light of day, only that it is barred with the bright lines of the substances in combustion. The flame of the spark, with a very slight blast of air, rises to at least 12 inches in height when it is passing about the same distance horizontally.

Besides the gigantic Grove's battery, there is also a Leyden battery in course of construction, the present one being inadequate to represent the full power of the coil. The first part of this battery, consisting of 250 square feet of coated glass, is now nearly completed. There is also a very large and elegant arrangement of Gassiott's cascade in course of construction, which is also to work with the great induction machine, and which will embody several important improvements that have been suggested by Mr. Gassiott. The most recent experiments with the coil have shown that as yet no limit as to the quantity of effects can be established, and it is exceedingly probable that by a very few minutes' working, the large coil would charge at least 1,000 Leyden jars of very large size.—*Mec. Mag.*

SPECTROSCOPIC OBSERVATIONS OF THE SUN.

By J. Norman Lockyer.

In a former paper the author stated that Dr. Frankland and himself had searched without success for the known third line of hydrogen in the spectrum of the chromosphere. He has now discovered that the position of the third line is at 2796 Kirchhoff's scale. The author assumes that the darkening of the limb is due to the general absorption of the chromosphere, and therefore it follows:

1. That the additional selective absorption near the limb is extremely probable.

2. That the hydrogen Fraunhofer lines indicating the absorption of the outer shell of the chromosphere will vary somewhat in thickness: this he found to be the case to a certain extent.

3. That it is not probable that the prominences will be visible on the sun's disc.

On the 20th of February a spot was observed in which the *general* absorption was so great that the several lines could only be distinguished with difficulty, except in the very brightest region, which is ascribed to the greater length of the absorbing medium in the spot itself in the line of sight when the spot is observed near the limit instead of the centre of the disc.

Mr. Lockyer has succeeded in adding magnesium and barium to the material (sodium) to which he referred in paper No. 1 (published in 1866). He no longer regards a spot simply as a cavity, but as a place in which principally the vapors of sodium, barium and magnesium occupy a lower position than they do ordinarily in the photosphere. It therefore follows:

1. The lines of sodium, magnesium and barium, when observed in a spot, are thicker than their usual Fraunhofer lines.

2. The lines of sodium, magnesium and barium, when observed in the chromosphere, are thinner than their usual Fraunhofer lines.

These facts give additional evidence that a spot is the seat of a downrush—a downrush to a region, as we now know, where the selective absorption of the upper strata is different from what it would be, and indeed is elsewhere at a higher level.

The author thinks there are two causes for the darkening of a spot, viz:

1. The general absorption of the chromosphere thicker here than elsewhere, as the spot is a cavity.

2. The greater selective absorption of the lower sodium, barium, magnesium stratum, as the surface of its last layer is below the ordinary level.

Mr. Lockyer is waiting to make observations with the large Stenheil spectroscope to finally test the accuracy of the valuable suggestion of Messrs. De la Rue, Stewart and Loewy, in their "Researches on Solar Physics," that if the photosphere of the sun be the plane of condensation of gaseous matter, the plane may be found to be subject to periodical elevations and depressions, and that at

the epoch of minimum sun-spot frequency the plane might be uplifted very high in the solar atmosphere, so that there is comparatively little cold absorbing atmosphere above it, and therefore great difficulty in forming a spot.

With a rapidly oscillating slit the author was not satisfied with his results, but on hearing that Mr. Huggins had succeeded in seeing the form of the solar protuberances, by using absorbing media and a wide slit, he was led to try the wide slit without the absorptive media, and in the following words he describes the results:— "The solar and atmospheric spectra being hidden, and the wide image of the slit alone being visible, the telescope or slit is moved slowly, and the strange shadow-forms flit past. Here one is reminded by the fleecy, infinitely delicate cloud-films of an English hedgerow with luxuriant elms; here of a densely intertwined tropical forest, the intimately interwoven branches threading in all directions, the prominences generally expanding as they mount upwards, and changing slowly, almost, indeed, imperceptibly. By this method the smallest details of the prominences and of the chromosphere itself are rendered perfectly visible and easy of observation."

In an addendum dated March 17th, the author states that more favorable weather had enabled him to continue his researches in reference to his method for viewing the prominences and to view the injection of sodium, magnesium, &c., into the chromosphere. He thinks that in time it will be possible to see the prominences as they really are seen in an eclipse by constructing a rapidly revolving wheel with red, green and violet glass of the required absorptions, in which the percentages of light of each color may be regulated. On the 14th of March, with a tangential slit, a fine dense prominence near the sun's equator on the eastern limb was observed.—*Chem. News.*

ON THE LIGHTNING SPECTRUM.

By Lieut. John Herschel, R. E.

I have had two or three opportunities of seeing this spectrum to advantage of late. The storms at the period of setting in of the south-west monsoon here are very frequent, and supply for a time almost incessant flashes, many of which are of course very brilliant. The first time I examined the light in the spectroscope I

had no idea of measuring, but was content to realize the principal facts of a continuous spectrum crossed by bright lines; but subsequently I made several attempts (with some success) to obtain measures. That I was unable to do more in this line is due partly to the difficulty of utilizing the short-lived appearance, partly to that fascination of waiting for "one more" bright flash to verify the intersection, which can only be thoroughly appreciated by the aid of a similar experience.

The principal features of the spectrum are a more or less bright continuous spectrum crossed by numerous bright lines, so numerous indeed as to perplex one as to their identity. This perplexity is increased by the constantly changing appearance due to a variable illuminating power. This variable character of the appearances is unquestionably the peculiar feature of the spectrum. It is not that the whole spectrum varies in brightness in the same degree, but that the *relative* intensities are variable, not only among the various lines, but between these and the continuous spectrum. The latter is sometimes very brilliant; and when that is the case, the red portion is very striking, though in general the spectrum seems to end abruptly at D + 0·34 (E = D + 1·38, Kirchhoff's 120·7 = D + 0·55.)

There is one principal line which I found equal to D + 2·20 as the result of five independent measures. The probable error of this value is about $\pm$·02. The general mean of all my measures of the principal *nebular* line (obtained from twelve different nebulæ) is 2·18, with a probable error of about $\pm$·02. I have therefore very little doubt that these are the same, viz.: the nitrogen line identified in the case of nebulæ of Mr. Huggins. This line in the lightning spectrum is narrow and sharply defined, and is conspicuously the brightest, except as noted below.

The next in prominence is situated about D + 3·58 (F = D + 2·73, Kirchhoff's 232·5 = D + 3·50). It is broader and less vivid, and not so well defined at the edges.

There are several other conspicuous lines, but none comparable to the first. I noticed a sharp line in the red, but did not get a measure.

I said that at D + 0·34 the continuous spectrum ends abruptly. A faint continuation is, however, seen frequently in bright flashes, very bright ones bringing out a brilliant red end crossed by a bright line.

The whole of the ordinary spectrum *seems* green and blue, or rather greenish blue; but as the usual prismatic order of colors is recognizable in bright flashes, it is to be inferred that the region from E to F is so much brighter as to give the character in question. What strikes one most, however, is the varying relative brightness of the continuous and linear spectra; sometimes the lines are scarcely seen, and sometimes very little else is seen. This may be nothing more than an illusion; but in the absence of any certainty that it is so, the impression left on the mind is worth recording.

The difficulty of discriminating between the many less prominent lines is immensely increased by the momentary character of the phenomenon. Before the mind has selected an individual, the feeble impression on the retina has vanished; and before another flash succeeds, the memory of the half-formed choice has vanished with it, and there is nothing on which to found a selection. Otherwise it would be easy enough to measure many more lines.

ON SOME OPTICAL PHENOMENA OF OPALS.

By William Crookes, F.R.S., &c.

By means of the spectrum microscope (described Vol. LIV., page 335 of this *Journal*), some curious optical phenomena of opals have been observed.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscope, or spectrum microscope, at the proper angle, the light is generally seen to be purely homogeneous, and all that is visible is a brilliant luminous line, varying somewhat in width, and more or less irregular in outline, but very sharp, and shining brightly on a perfectly black ground. If a source of light is now moved so as to shine into the spectrum apparatus through the opal, the above appearance is reversed, and we have a luminous spectrum with a jet-black absorption band in the red, identical in position, form of outline and sharpness, with the luminous line previously observed.

From these and other experiments, it has been found that those parts of the opal which emit red, yellow, green or blue light, are opaque to light of the same refrangibility which they emit. This is doubtless a general law, following of necessity the mode of production of the flashes of color.

From the description of the absorption phenomena of a series of opals, the following are selected as the most striking:—

No. 1 shows a single black band in the red. When properly in focus, this has a spiral structure. Examined with both eyes, it appears in decided relief, and the arrangement of light and shade is such as to produce a resemblance to a twisted column.

No. 2 gives an irregular line in the orange. Viewed binocularly, this exhibits the spiral structure in a marked manner, the different depths and distances standing well out; upon turning the milled head of the stage adjustment so as to carry the opal slowly from left to right, the line is seen to revolve and roll over, altering its shape and its position in the spectrum. It is not easy to retain the conviction that one is looking merely at an absorption band in the spectrum, and not at a solid body possessing dimensions and in actual motion.

No. 9 shows a very sharp and black band stretching diagonally across the green, touching the blue at the top, and the yellow at the bottom.

No. 12 gives a narrow, straight, and sharply-cut line in the green; this might easily be mistaken for an absorption band caused by an unknown chemical element.

Other opals show an absorption band traveling along the spectrum, almost from one end to the other, as the opal is moved sideways. All these black bands can be reversed, and changed into luminous bands, by examining the opal with reflected light.

ON THE LOWERING OF TEMPERATURE DUE TO THE SOLUTION OF SALTS IN WATER.

THE decrease of temperature will be the greater the larger the quantity of any salt which water takes up at a certain given temperature. Since, however, water at a certain temperature only dissolves a definite quantity of any salt, the maximum decrease of temperature will be about that at which, under given circumstances, a fully saturated solution is produced. When, therefore, the salt and the water are applied in the proportion where from a saturated solution results, a long period of time elapses before the last portions of the salt are entirely dissolved, and the effect of the warm ambient air to some extent vitiates the proper results of the experiments; the saturated solution should therefore be obtained as

rapidly as possible. The experiments were conducted in the following manner:—The finely-powdered salt and the requisite quantities of water were, previous to the making of the experiments, each put in separate beakers made of very thin glass, and placed, for from 12 to 18 hours, in a room wherein the temperature could be kept as nearly as possible constant; in consequence of this the beakers and contents attained the same temperature throughout. The mixing was effected by pouring the water on to the salt, and stirring up with a very delicate and highly sensitive thermometer; the maximum decrease of temperature took place within a minute after the mixing of the salt and water was made. The results of the experiments are exhibited in the following tabulated form, recording the average of a series of several experiments with one and the same substance, which were concordant within 0·2°:—

	Soluble in 100 parts of water.	Mixed with 100 parts of water.	The temperature falls		Number of Degrees.
			From °C.	To °C.	°C.
Crystallized alum	10·0	14	+10·8	+ 9·4	1·4
Chloride of sodium	35·8	36	12·6	+10·1	2·5
Sulphate of potassa	9·9	12	14·7	+11·7	3·0
Crystallized phosphate of soda	9·0	14	10·8	+ 7·1	3·7
Sulphate of ammonia	72·3	75	13·2	+ 6·8	6·4
Sulphate of soda (crystals)	16·8	20	12·5	+ 5·7	6·8
Sulphate of magnesia (crystals)	80·0	85	11·1	+ 3·1	8·0
Carbonate of soda (crystals)	30·0	40	10·7	+ 1·6	9·1
Nitrate of potassa	15·5	16	13·2	+ 3·0	10·2
Chloride of potassium	28·6	30	13·2	+ 0·6	12·6
Carbonate of ammonia	25·0	30	15·3	+ 3·2	12·1
Acetate of soda (crystals)	80·0	85	10·7	— 4·7	15·4
Chloride of ammonium	28·2	30	13·3	— 5·1	18·4
Nitrate of soda	69·0	75	13·2	— 5·3	18·5
Hyposulphite of soda (crystals)	98·0	110	10·7	— 8·0	18·7
Iodide of potassium	120·0	140	10·8	—11·7	22·5
Chloride of calcium (crystallized)	200·0	250	10·8	—12·4	23·2
Nitrate of ammonia	55·0	60	13·6	—13·6	27·2
Sulphocyanide of ammonium	105·0	133	13·2	—18·0	31·2
Sulphocyanide of potassium	130·0	150	10·8	—23·7	34·5

The quantity of water applied varied between 250 and 500 grammes, and the quantity of salt used corresponded therewith. The decrease of temperature obtainable in this manner can never fall below the freezing point of the saline solution in question, but can very nearly reach that. The sulphocyanide of potassium is the best salt to be adopted for the artificial production of ice; when 500 grammes of this salt are dissolved in 400 cubic centimetres of water, and the mixture stirred with a test-tube filled with water, the latter will be frozen in from two to three minutes. The degree of solubility of the salts referred to in the first column is made up according to G. J. Mulder's highly elaborate researches on this subject.—*Chem. News.*

ON THE METHODS AND RECENT PROGRESS OF SPECTRUM ANALYSIS.

By A. S. Herschel, B.A., F.R.A.S.

[Professor of Natural Philosophy in the Andersonian University of Glasgow.]

The portion of the solar spectrum which is most generally visible under all circumstances of the atmosphere, and in which the bright-line spectra of the metals obtained with the spark of a Rhumkorff coil are mostly seen, is that contained between the Fraunhofer's dark lines A and G, at the least and most refrangible ends of the spectrum as it appears in Kirchhoff's maps, the last of which was published in 1863. The air-spectrum between the poles of an induction coil was subsequently employed by Mr. Huggins in his "Researches on the Spectra of some of the Chemical Elements," published in the *Philosophical Transactions* for 1864, as a standard of comparison with the bright-line spectra of the metals produced together with it in the induction spark. The superior heat of the voltaic arc being found to produce more vivid spectra of the elements, and to exhibit lines in the violet portion not usually seen with the induction coil, a blue line in the spectrum of lithium was thus discovered by Professor Tyndall in addition to the orange line which Dr. Bunsen had detected in it by the application of a Rhumkorff coil. To extend Kirchhoff's scale of reference to the wider range of artificial spectra, the labor of completing the map of the solar spectrum by delineating the violet portion, and comparing it with the voltaic spectra of the chemical elements was carried out by Professor Angstöm, with the assistance of Mr. R.

Thalén, at Upsala; and the work was published in the *Proceedings of the Stockholm Academy* for February, 1865. Confining their attention chiefly to the iron spectrum produced by two stout iron poles of a Bunsen Battery of 50 cells, the specimen of this metal was found to contain so many bright lines, especially in the violet portion, that, in addition to 73 iron lines found by Kirchhoff and Hofmann to have counterparts in the dark solar lines between A and G, about 220 were added to the number in that space and 170 more between G and H making the whole number of iron coincidences about 460, to which, it was believed, one or two hundred might have been added, had not the short summer and deficient sunlight in the high northern latitude put an end to their comparisons. With a greater battery power, and an equally extensive trial of other chemical elements, whose vapors appear to be present in the sun, the probability was suggested that the innumerable black lines of the solar spectrum, which still remain outstanding when those of iron are subtracted, may at length be accounted for without assuming the existence of chemical elements in the solar atmosphere, with which we are unacquainted on the earth. The solar character of four new sodium lines, which were first pointed out and their coincidence with Fraunhofer's was suspected by Mr. Huggins in his researches, was confirmed; while the agreement of a prominent dark line about half way between G and H, designated *h* by the authors, with a fourth line of the spectrum of incandescent hydrogen was established, proving with the correspondences of the other lines at C, F and G, the existence of that element in the sun. The metal manganese was placed, for the first time, on the list of solar elements, and 50 new correspondences of calcium lines were noted in addition to those already previously observed by Kirchhoff. In a Swedish work on spectrum analysis,* published in the following year, Mr. Thalén has compiled a very complete chart of spectra of the chemical elements, referred, like the above-mentioned chart of Mr. Huggins, to the bright lines of incandescent air, and continued, as far as they could be traced, to the violet end of the spectrum. It will easily be perceived that the addition of so many characteristic bright lines in the spectra of the chemical elements, by the use of the voltaic arc, by giving greater certainty to the results, facilitates, in a corresponding degree, the practical applica-

* "Spectralanalys, Exposé och Historik; Med en Spektrelkarta." Af Rob. Thalén, Upsala, Edquist & Berglund, 1866.

tions of the spectroscope. Moreover, in order to establish a natural scale for the uniform representation of artificial spectra, Professor Angström last year published a Normal Atlas of the Solar Spectrum,* in which the wave lengths of the Fraunhofer lines are employed to delineate them, so that the spaces between them represent the differences of their wave lengths enlarged to ten million times their natural dimensions. The most refrangible Fraunhofer line, H, occupies a point at 3,933 millimetres, and the least refrangible line, *a*, a point at 7,185 millimetres on the map, which are ten million times the wave lengths of those lines; and the entire map, consisting of six plates of two lines each, is 11 feet 6 inches in length. The violet end of the spectrum in this projection is more compressed, and the red end more expanded, than corresponds to their natural appearance. If, however, in place of the wave lengths the number of impulses in a second, or their scale of pitch, as in musical notes, were employed for projecting the Fraunhofer's lines, a nearly natural representation of the prismatic spectrum would be obtained; and the above objection to the use of the normal scale, which may not, however, be of very great theoretical importance, might yet practically be removed with some advantage. A series of elementary bright-line spectra, showing their counterparts among the solar lines, is laid down in the margin of the map, with the following numbers of the corresponding lines of each, in their correct places on the scale, viz:—Iron, 450; titanium, 116; calcium, 68; manganese, 63; nickel, 35; cobalt, 19; chromium, 18; barium, 10; sodium, 9;† magnesium, 7; copper, 7; zinc (blue lines), 2; aluminium (violet lines), 2; hydrogen, 4. By a series of remarkable coincidences, if not of absolute agreements, twenty-four lines of titanium, twenty-one of calcium, and four lines of manganese, are represented in the map as corresponding exactly in their positions with iron lines. A similar agreement between a double line of nitrogen and a double line of oxygen was observed by Mr. Huggins in the spectrum of incandescent air,‡ but as the correspondence appeared, on closer examination, not to be absolutely perfect, it was shown to be

* "Spectre Normal du Soliel;" par A. J. Angström, Upsal, 1868. The plates are drawn by Mr. Thalén.

† Three of the new lines of the sodium spectrum are double, like the familiar D line, and the fourth is a narrow nebulus line, making the total number of nine separate bright lines in the spectrum of this vapor.

‡ "Researches on the Spectra of some of the Chemical Elements." *Philosophical Transactions* for 1864, part ii.

probably an accidental, although certainly a most curious, coincidence. In Angström's Normal Atlas the air spectrum is placed on a parallel line with the solar spectrum, extending throughout its length so as to include the lines of the elementary spectra between them. The comparison of the latter with either of the two standard scales is, accordingly, made a matter of easy reference. At the end of the atlas is placed a chart of the atmospheric dark lines and spaces of the solar spectrum, a large number of which are now known to owe their presence in it to the absorption produced by aqueous vapor in the earth's atmosphere. This cloudy group of lines is well characterized by Mr. Thalén as forming a faint ground, from which the true solar lines of the inverted metallic spectra, tolerably deep black and well defined, stand out, as if seen in perspective, in strong relief. In place of the four glass prisms used by Mr. Kirchhoff in his researches, a single bisulphide of carbon prism with a refracting angle of 60°, a collimator, and an astronomical telescope, each magnifying forty times, were found to be a sufficiently powerful apparatus to distinguish all the lines shown in Kirchhoff's maps, and to add to them the numerous lines recorded in the above-mentioned drawings by Mr. Thalén. From the foregoing description of their recent publications, it will be seen that the operations of the Swedish observers continue to afford fresh data of practical value to spectral analysis, as well as some very important contributions of a novel and interesting kind of spectroscopic science.

CONTRIBUTIONS TO THE HISTORY OF EXPLOSIVE AGENTS.

By F. A. Abel, F.R.S., For. Sec. C. S.

The degree of rapidity with which an explosive substance undergoes metamorphosis, as also the nature and results of such change, are, in the greater number of instances, susceptible of several modifications by variation of the circumstances under which the conditions essential to chemical change are fulfilled.

Excellent illustrations of the modes by which such modifications may be brought about are furnished by gun-cotton, which may be made to burn very slowly, almost without flame, to inflame with great rapidity, but without development of great explosive force, or to exercise a violent destructive action, according as the mode of

applying heat, the circumstances attending such application of heat, and the mechanical condition of the explosive agent are modified.* The character of explosion and the mechanical force developed within given periods by the metamorphosis of explosive mixtures, such as gunpowder, is similarly subject to modifications; and even the most violent explosive compounds known (the mercuric and silver fulminates, and the chloride and iodide of nitrogen,) behave in very different ways under the operation of heat or other disturbing influences, according to the circumstances which attend the metamorphosis of the explosive agent (*e. g.*, the position of the source of heat with reference to the mass of the substance to be exploded, or the extent of initial resistance opposed to the escape of the products of explosion).

Some new and striking illustrations have been obtained of the susceptibility to modification in explosive action possessed by these substances.

The product of the action of nitric acid upon glycerine, known as nitro-glycerine or glonoine, which bears some resemblance to chloride of nitrogen in its power of sudden explosion, requires the fulfilment of special conditions for the development of its explosive force. Its explosion by the simple application of heat can only be accomplished if the source of heat be applied, for a protracted period, in such a way that chemical decomposition is established in some portions of the mass, and is favored by the continued application of heat to that part. Under these circumstances, the chemical change proceeds with very rapidly accelerating violence, and the sudden transformation into gaseous products of the heated portion eventually results, a transformation which is instantly communicated throughout the mass of nitro-glycerine, so that confinement of the substance is not necessary to develop its full explosive force. This result can be obtained more expeditiously and with greater certainty by exposing the substance to the concussive action of a detonation produced by the ignition of a small quantity of fulminating powder, closely confined and placed in contact with, or proximity to, the nitro-glycerine.

The development of the violent explosive action of nitro-glycerine, freely exposed to air, through the agency of a detonation, was regarded until recently as a peculiarity of that substance; it is now demonstrated that gun-cotton and other explosive compounds and

* *Proceedings of the Royal Society*, Vol. XIII., pp. 205 *et seq.*

mixtures do not necessarily require confinement for the full development of their explosive force, but that this result is attainable (and very readily, in some instances, especially in the case of gun-cotton,) by means similar to those applied in the case of nitro-glycerine.

The manner in which a detonation operates in determining the violent explosion of gun-cotton, nitro-glycerine, &c., has been made the subject of careful investigation. It is demonstrated experimentally that the result cannot be ascribed to the direct operation of the heat developed by the chemical changes of the charge of detonating material used as the exploding agent. An experimental comparison of the mechanical force exerted by different explosive compounds, and by the same compound employed in different ways, has shown that the remarkable power possessed by the explosion of small quantities of certain bodies (the mercuric and silver fulminates) to accomplish the detonation of gun-cotton, while comparatively very large quantities of other highly explosive agents are incapable of producing that result, is generally accounted for satisfactorily by the difference of force suddenly brought to bear in the different instances upon some portion of the mass operated upon. Most generally, therefore, the degree of facility with which the detonation of a substance will develop similar change in a neighboring explosive substance, may be regarded as proportionate to the amount of force developed within the shortest period of time by that detonation, the latter being, in fact, analogous in its operation to that of a blow from a hammer, or of the impact of a projectile.

Several remarkable results of an exceptional character have been obtained, which indicate that the development of explosive force under the circumstances referred to is not always simply ascribable to the sudden operation of mechanical force. These were especially observed in the course of a comparison of the conditions essential to the detonation of gun-cotton and of nitro-glycerine by means of particular explosive agents, (chloride of nitrogen, &c.,) as well as in an examination into the effects produced upon each other by the detonation of those two substances.

The explanation offered of these exceptional results is to the effect that the vibrations attendant upon a particular explosion, if synchronous with those which would result from the explosion of a neighboring substance in a state of high chemical tension, will by

their tendency to develope those vibrations, either determine the explosion of that substance, or at any rate greatly aid the disturbing effect of mechanical force suddenly applied, while, in the instance of another explosion, which developes vibratory impulses of different character, the mechanical force applied through its agency has to operate with little or no aid; greater force, or a more powerful detonation, being therefore required in the latter instance to accomplish the same result.

Instances of the apparently simultaneous explosion of numerous distinct and even somewhat widely separated masses of explosive substances (such as simultaneous explosions in several distinct buildings at powder-mills,) do not unfrequently occur, in which the generation of a disruptive impulse by the first or initiative explosion, which is communicated with extreme rapidity to contiguous masses of the same nature, appears much more likely to be the operating cause, than that such simultaneous explosions should be brought about by the direct operation of heat and mechanical force.

A practical examination has been instituted into the influence which the explosion of gun cotton, through the agency of a detonation, exercises upon the nature of its metamorphosis, upon the character and effects of its explosion, and upon the uses to which gun-cotton is susceptible of application.—*Chem. News.*

A New Air-Pump.—An instrument of this nature has been lately devised by Bunsen, which, as a stationary attachment to a laboratory will, no doubt, prove of great and general service. It consists, essentially, of a concentric nozzle at the top of a small lead pipe, about $\frac{3}{16}$ inch = 8 milimetres in diameter, and about 40 feet long, having a water supply flowing through the outer part of the jet, and sucking air in a series of bubbles from the inner jet, which is connected with the vessel to be exhausted. This arrangement will, at any time, give a vacuum equal to the tension of the vapor of water at the existing temperature. To exhaust a flask of 1 to 3 litre (·88 to 2½ quarts) requires from 6 to 10 minutes, and expends 40 to 50 litres (8½ to 10½ gallons) of water.

The advantage of being able to *turn on a vacuum* with a stopcock, and exhaust corrosive gases without injury to apparatus, afforded by this device, is of very great importance.

EDUCATIONAL

SPECTRUM ANALYSIS.

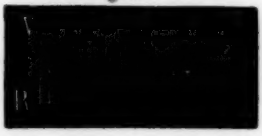
By Prof. Henry Morton, Ph. D.

The subject of spectrum analysis is one, which, by reason of its rapid development in connection with practical matters and the general business of life, is at present exciting the interest of many who have not before given to it any attention. Like every other great and new discovery, it excited interest among a certain class, at first, by a mere force of novelty, but failed by that claim to establish its value in the eyes of the general community. But it has now reached that stage of development when its claims must be recognized by all, and thus many of those who ignored its early developments and primitive stages of advance, now are asking for information as to its character, principles and applications; and for their benefit we propose to publish a concise account of the first principles of this wonderful process, by means of which we are enabled to deal at equal advantage with the inappreciably small and the immeasurably great; to discover the presence of the one two hundred-millionth of a grain of salt floating in the air, and to analyze every star and nebula in the universe. By which we can look into and follow more closely than by any other aid, those mysterious changes in the structure of substances which are concerned in the microscopic phenomena of life; and with which we can likewise detect the changes which may be progressing in the growth of a solar system, and translate to our comprehension the passing incidents in the physical history of an universe.

The elementary facts and principles upon which this wonderful process is based are, after all, few and simple. If a ray of white light, passing through a narrow crack, so that it might be represented in its entire path by a strip of paper, falls upon a glass prism so as to have its narrowest edges towards the triangular ends, and its breadth parallel with the three parallel edges of the glass, it will be bent from its course, as is shown in the figure, and, moreover, will be spread out so as to produce on a screen a band or ribbon of light which will have a red color at the end, R, a violet color

at the other end, V, and all the other pure colors, orange, yellow, green, blue, with all their possible gradations, blending gradually between. Such a band of colored light is called a "spectrum," or, accurately, a "continuous spectrum."

Fig. 1.



The significance of this simple experiment will be appreciated when the following facts, proved in many other ways beside, are borne in mind:—

White light is a composition of all pure colors, and the simple, or pure and unmixed, thing, in light, is not white, but any single color. Each simple color is bent or deflected by a prism, to a certain degree peculiar to itself; and thus, when the mingled white ray falls upon the prism, each of its constituent colors, being differently deflected, follows a different path, and so comes to a different place; and thus the individual tints are "deployed in line," and appear side by side.

Were the ray which falls upon the prism composed of a single color, no such outspreading could occur; all the light would be equally bent, would follow the same path, and would produce on the screen a narrow line exactly similar in shape to the opening through which the beam was admitted at first. Thus, if the light were of a simple red tint, it would go to some point near R; if of a violet shade, to some one spot near V; or if orange, yellow, or green, to its appropriate place between the first-mentioned extremities.

If, again, the color in the light were mixed—if the ray consisted of a certain yellow ray and a certain blue one combined—then, after traversing the prism, the blue part would go to its place, and the yellow to its own, and the rest would be unilluminated or dark. Thus would the mixed light be "analyzed" by such a development into an incomplete and fragmentary spectrum, which is, however, called a "spectrum," nevertheless.

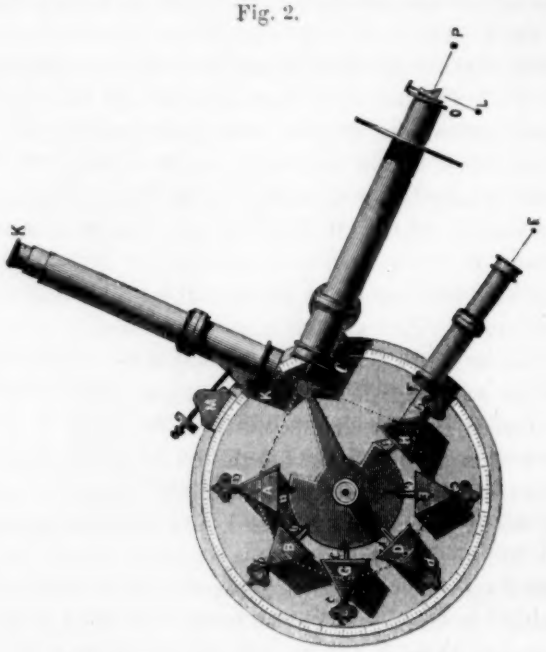
We should further mention here, that the difference between colors in light is exactly the same as that between notes in music, namely: a variation in the rapidity of vibration. Thus, the note C, or "do," of the lowest octave, is produced by, or consists of, 128 vibrations per second; D, or "re," of 144, and so on; and in like manner crimson light is produced by 473,000,000,000,000 vibrations per second, and bright blue by 653,000,000,000,000.

The separation effected by the prism in the case before described, is, therefore, in fact, a sort of numerical classification by which the vibrations of different rates are sorted out, and each sent to its own place in the rank, according to a regular numerical progression. To follow out our musical analogy or illustration, it would be paralleled in the case of sound, could we, by some sort of acoustic prism, separate the various notes coming from an orchestra, and cause each to fall in its appropriate place on the key-board of a piano.

The general principle being such as we have above described, the method by which it is practically applied to purposes of analysis is as follows:—

An instrument called a "spectroscope" is provided, which is constructed in the following manner (see Fig. 2, which is a view of the apparatus as seen from directly above): Attached to a firm

Fig. 2.



stand having a flat circular top, is a tube, C O, having at its end, O, a narrow vertical opening adjustable as to its width by means of a slide and screw. Half the height of this opening is covered by a small triangular glass prism, by which rays of light from L will be

reflected into the tube through that half of the opening, while the other half is uncovered and will admit light from P, directly in front.

We will at first only consider these last rays, which may be supposed to come from a lamp or burner at P, and to pass down the tube, C O. At the end, C, of this tube, these rays encounter a lens, which renders them parallel to one another, and in this condition they fall upon a prism, A, by which they are refracted and separated in the manner already described, and fall, in turn, upon a prism, B, which bends them around to C; this then sends them to D, and so on to H, from which they pass off in the direction H K, and thus enter this tube, K K, which is simply a small telescope, to the outer end of which the eye of the observer is applied.

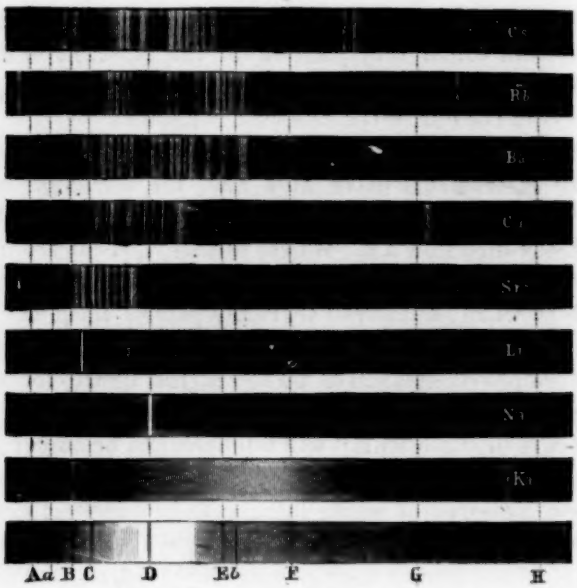
It is not always or generally necessary to employ so many prisms. Ordinary instruments have only one, the telescope being then placed so as to receive the rays as they leave this first and only prism in the direction A B. Where so many prisms are used, moreover, all the rays cannot be seen at once, as, after the second prism, they are so widely outspread that only part of them fall upon the next prism, and so on, more and more to the last: an arrangement is therefore provided (such as we see in the figure) for so turning all the prisms together that one part after another of the outspread band of rays or "spectrum" will fall upon and be observed through the telescope.

If, then, a source of white light, such as a candle, lamp, or gas-flame is placed at P, its various colored rays will be separated by the action of the one or more prisms employed, and the distributed, separated, or analyzed light or "spectrum," will be observed in detail by means of the telescope at K.

If, however, a source of light is placed at P, which furnishes rays of but one color (as, for example, a spirit-lamp with table salt on the wick, which gives pure yellow light), then the rays will not be separated by the prisms, but will all be bent equally and together, and we shall see through the telescope a yellow image of the narrow opening by which the light enters the tube, C O, exactly as though we were looking directly towards it. This image will occupy exactly the place of the same color (yellow) in the continuous spectrum obtained with the white light. In fact, we may very fairly regard the continuous spectrum as being made up of a row of colored images of the narrow opening, arranged side by side; this

arrangement being due to the fact that each color is differently bent by the prisms. If the light placed at P, instead of emitting one color, gave out two, three, four, or more distinct colors, but not every shade, then each of these tints would be thrown to its appropriate place, and we should have a spectrum consisting of two, three, four, or more colored bands distributed on a black ground. This is illustrated in Fig 3, where all the "spectra," except the last, are of this character.

Fig. 3.



It is a fact, proved by extended observation and experiment, that when substances are so heated as to be vaporized and made luminous at the same time, the light which they emit is made up of a moderate number of colors, wanting a great part of the various shades which would make up a complete series or continuous spectrum; and that, moreover, the colors emitted by each substance are peculiar to itself, and, under similar conditions, always the same for the same body. If, then, we heat an unknown substance in the colorless flame of an alcohol lamp, or Bunsen burner, and look at the light its vapor emits, through a spectroscope such as is shown in Fig. 2, and we see a single vertical yellow line, as in the band marked Na. on Fig. 3, we may know that the substance employed contains sodium. If we see a rich red and an orange line,

as in band marked Li., we know that lithmus is present, and so on with the others, Sr. standing for strontium, Ca. for calcium, Ba. for barium, Rb. for rubidium, Cs. for cæsium, and Ka. for potassium.

These lines are here shown without their colors, but these may be estimated by remembering that the lower band represents a spectrum of sunlight with its red end at A, bright crimson at C, orange at D, and yellow beyond; green about E, blue beginning about F, indigo near G, and violet either side of H, and that like colors occupy corresponding places in the bands below.

For the more accurate determination of lines, measurements are made by means of a transparent scale placed in the outer end of the tube, F, and illuminated by a light at F, its image being reflected from the face of the prism H so as to enter the telescope, K, along with the rays producing the spectrum, so that the divided scale seems to be a transparent rule lying upon the spectrum.

The object of the little prism at the end of the tube, C O, is to enable us to compare the spectra of the two lights, one being placed at L and one at P. The light from P goes through the part of the slit not covered by the prism, while that from L goes by the other part, and so two spectra are seen at once, one above the other.

By the use of such an instrument as we have described, it is evident that the presence or absence of a large number of substances in minerals, and like bodies, may be ascertained with great ease and rapidity. To facilitate such operations, a few adjuncts are of great advantage. Thus, beside a pair of Bunsen burners of the usual sort, a couple of light stands, furnished with projecting adjustable wires, over which short pieces of glass tubing with platinum wires attached to their outer ends will slip. These platinum wires, bent into a loop, will hold in the flame of the burners, morsels of the substances to be tested. Where a higher temperature than that of the Bunsen burner is required, the oxohydrogen flame is sometimes employed; but, usually, those substances which will not volatilize in the ordinary Bunsen burner, must be treated with the vastly higher temperature of the electric discharge. This is most conveniently obtained by the use of the induction coil with Leyden jars in circuit. The substances to be examined are then adjusted as terminal points, between which the spark leaps either in the air or within glass tubes; or, if the material be liquid or gaseous, it is enclosed in a tube more or less exhausted, and supplied with conducting wires soldered into its ends.

By extended investigations, certain laws or general rules of action have been developed in reference to the relation of various forms of matter and their spectra, which are of the greatest importance, on account of their application to the solution of many natural problems otherwise quite beyond our reach. This subject we must, however, defer until the next number.

(To be continued.)

ON THE FUTURE DEVELOPMENT OF SCIENTIFIC EDUCATION IN AMERICA.

By S. Edward Warren, C. E.

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(Concluded from Vol. LVII., page 422.)

(*D.*)—*Philosophy.* Passing over, without further comment, than has already been made, such classes of studies as are at present popular and appreciated, and noting only those which are misapprehended and regarded with some prejudice, philosophy must have a word in its behalf. It is no wonder that those who deal with obviously fruitful facts and thoughts, and who have been well nigh consumed with laughter, in reading of the successive and dissimilar rocket flights of some philosophies, and at the transient and very much unmeaning applause that greeted each, should think the very word philosophy a synonym for such ingenious vagary, as any one could write to order by the yard, for the amusement of a lively company. But there *is* a philosophy, of plain sound Scotch, or other common sense, to which a dash of French brilliancy does no harm; which consists in an orderly discussion of facts and principles; well ascertained by patient interrogation of consciousness, and observation of life, similar to those employed in physical researches. Such philosophy must be both interesting and improving, by as much as the human spirit is a reality, having ascertainable attributes and relations.

We only add, that philosophy is here used in a broad sense, to include *Psychology*, or mental structure; *Logic*, or the science of the necessary forms of thought, *Ethics*, or moral science, and *Æsthetics*, or the science of beauty.

(*E.*)—*Practice.* Man, considered as not a *structure*, merely, but an *agent*, to be perfected; and, still more, as a *complex*, and not a

simple agent, since he is composed of a united body and spirit, should be trained by a thoroughly concrete system of education; that is, one in which manipulations, governed by principles, and resulting in visibly or tangibly *embodied* principles, shall have a due share. For the spirit to keep the flesh forever innocently busy, in working out some work of the governing intelligence, is not merely an incomparable moral safeguard, and that in the sweetest way, by securing perennial delight in life, but it educates the actual concrete man, of body and soul, up to a perfect practical unity of being, by making the body the sure and accomplished servant of the soul; by putting every physical capacity fully into the grasp of the *self*-possessed spirit. Physical, chemical, geodetical, graphical, gymnastic and vocal *practice*, with a full understanding of the principles involved, is a grand division of noble educating agencies, which have not always been sufficiently recognized, even in otherwise masterly and comprehensive reviews of the business and objects of education.

Moreover, it is in the light of these remarks, and more clearly than before, perhaps, that we see, that general, or "liberal," and technical or "professional" education are properly less distinct in real life, than in systems of thought.

(*F.*)—Observation and experiment, we would now thus unite.

Observation { Simple = Of *Free* Man and Nature.
Condition = Of humanly conditioned Man or Nature = Experiment.

With these comments we proceed with the final two years of the proposed five years programme.

Technical Courses—Two Years.

Idea.—Without the perception of a noble idea at the bottom of technical instruction, it cannot be redeemed from the comparative disesteem evidently felt for it by some. There is such an idea of the very highest order, and only a strange failure to perceive it seems to have caused the disesteem alluded to.

The evil pride of life has apparently caused man to catch, if only obscurely, at the idea of a lofty aristocracy of learning, in connection with the idea of a university as a place of elegant retirement, for purposes of self culture, simply for its own sake. Let us therefore go at once to the foundation of life to see what can there be found, and thence, how to build.

The elements of life are being, doing, having; the perfection of each, as before said, is the sum of *good.* University, or college education, both being the same in spirit, so far as they only contemplate self-culture on the part of their members, aim in this spirit, to make perfection of *being* alone their end, in other words to make man an end to himself, as it is often expressed.

Now, a being so readily subject to illusions as man, may far too readily adopt the *apparently* lofty, but according to the deepest truth, belittleing idea of superlative greatness in thus withdrawing from industrial life in behalf of a life of elegant self-culture; supported by the industry of others, and earning for him an obsequious regard, which is in reality superstitious, as the following considerations shall plainly show; premising that we mean by superstitious regard, a deference beyond and in place of that which is *naturally* due, according to the real truth of things.

Professional education aims to perfect the *doing*, and that for the sake of the *having*, which perfect *doing* will certainly secure. Now, it is just here that a fatal oversight is made. First, there is nothing necessarily ignoble in study pursued in behalf of material self-service. For the actual world being most thoroughly a concrete one of matter united with and subject to controlling life, the *form* and *quality*, not necessarily the *amount*, of one's material acquisitions, are a fair exponent or expression of his capacities and personal soundness and worth. God has conditioned beautiful practical living, in which material things possessed are wielded for spiritual ends, upon well directed industry. Each is therefore bound to show to all, *his* characteristic specimen of the beautiful results of *his* peculiar form of industry. But, second, service is not by any means necessarily self-service.

It is not so in *effect*, even if so in *spirit.* But it is not necessarily so in spirit. And, now, can a noble progression end in a nobler conclusion than this following? Perfection of *being*, that the being, as an instrument, shall be capable of perfect *doing.* Perfect doing, for the sake of perfect *having*, and this last, in its use, the practical contribution which one consciously, intentionally and gladly makes to the glory of God as his Creator; to the blessing of man as his brother.

But only technical or professional education contemplates that exact determinateness, which makes perfect doing, and effects perfect having.

Wherefore, while the spirit of general or collegiate education, when it becomes partisan and dissociated from the best ideal professional spirit, has for its motto knowledge, admiration (of self and of things which exalt self), self-exaltation, and while the professional spirit, when depraved and fallen, contemplating only *selfish* self-service, with the least of broad or deep intelligence in the use of means to that end, is only a "bread and butter" spirit; the true professional spirit, reinforcing itself by intimate union with a just university spirit, takes for *its* symbol: *knowledge, admiration, love, service. Knowledge* of that form and extent that may be universally serviceable: *Admiration* of knowledge for both its subjective and objective benefits: *Love* to the Provider at once of the knowing faculties, on the one hand, and of honorable truth on the other; and to man for whom truth is to be reduced to practice. *Service*, joyfully rendered to the Creator, for the sake of his goodness, and to the creature for the sake of his needs.

We now return to our programme. Of the special courses in an engineering school, much is common to all. The following programme, may represent the course for the section of Construction Engineers.

First Year = Division B.

SUBJECT.	NO. HOURS ON DUTY.
Rational Mechanics	80
Physical "	40
Spherical Astronomy	30
Theory of Acoustics and Optics	25
" Structures	60
Technical Physics, Warming, Ventilation, Tests of Materials, Discharge of Liquids, etc.	60
Natural History, Origin and Preparation of Engineering Materials	30
Machine Construction and Drawing, Elements	50
Practical Chemistry, Qualitative Analysis	50
" Astronomy	60
" Trigonometry, Leveling and Topographical Surveying	60
Hydrographical Surveying	60
Contour Maps	15
Hydrographical Maps	30
Structure Drawing	60
Contingent	50
	750

Second Year = Division A.

SUBJECT.	NO. HOURS ON DUTY.
Engineering Geology	20
General and Iron Metallurgy	35
Manufacture of Machines	20
History and Processes of the Useful Arts	30
Flow of Streams, Experimental Determinations	15
History of Engineering	20
Practical Chemistry	25
" Meteorology	20
Engineering Chemistry, Preservation of Materials	25
Lectures on Special Engineering Operations by Experts	45
Railway Administration and Economy	30
Machine Construction and Drawing	20
Theory of Machines, General and Locomotive Motors	90
General and Engineering Architecture	30
Stone Cutting, Carpentry and Stairs	55
Railroad Surveying and Construction (Lectures)	40
Higher Geodesy, Elements	15
General and Engineering Jurisprudence	20
Engineering Æsthetics	20
Political Economy	25
Constitution of the United States	10
Road Engineering, Practice	40
R. R. Maps	20
Theses	50
Contingent	50
	750

The Cause of the Hardening of Hydraulic Cement.—In order to test the truth of the different hypotheses made concerning to this subject, A. Schulatschenko, seeing the impossibility of separating, from a mixture of silicates, each special combination thereof, repeated Fuchs's experiment, by separating the silica from 100 parts of pure soluble silicate of potassa, and, after mixing it with fifty parts of lime and placing the mass under water, when it hardened rapidly. A similar mixture was submitted to a very high temperature, and in this case, also, a cement was made. As a third experiment, a similar mixture was heated till it was fused; after having been cooled and pulverised, the fused mass did not harden any more under water. Hence it follows that hardening does take place in cement made by the wet as well as the dry process, and that the so-called over-burned cement is inactive, in consequence of its particles having suffered a physical change.

Bibliographical Notices.

We have received from Prof. Leeds, now residing in Berlin, the following reviews and abstracts of new German publications, which will, no doubt, be of special value to our readers, as the books themselves are not likely to be easily accessible, and these full discussions may thus represent them.—[Ed.]

Grundzüge der Krystallographie. By Dr. J. Müller. Second edition. Braunschweig: Vieweg & Son. 1868.

A great variety of discoveries in natural philosophy has shown that there is an intimate relation between the physical properties of substances and their crystalline form. If the three imaginary lines or axes around which the mass of a crystal is symetrically disposed are equal in length and at right angles to each other, then are its physical properties in these three directions the same. But, if such is not the case—if these axes are unequal in length and oblique, there is, on the contrary, not only a different conductibility for heat and electricity, an unequal degree of hardness and cohesion in dissimilar parts of the crystal, but even the rays of light are dissimilarly affected. The crystalline form is the external expression of the peculiar physical properties of a substance: it reveals at a glance what otherwise could be gathered only from many experiments. Although a growing appreciation of the importance of these facts, not merely by mineralogists and physicists, but also by chemists, has caused a larger and larger space to be devoted to Crystallography in works on Natural Philosophy and Chemical Physics, yet there is still a want of a compendium in English treating of this subject alone.

This work by Müller, at present under consideration, is plentifully illustrated with good wood-cuts, is clearly written, and as an easily-understood introduction to the science has a certain small value. Something more extensive is demanded at the present time. A work is wanted which will give the fundamental forms and all the known modifications. The different systems of lettering should be given, and the relation between the secondary and primary forms thoroughly explained. Something of this kind is requisite even to the mineralogist, to enable him fully to understand those

portions of the last edition of Dana's Mineralogy which relate to crystalline forms. For the system there given, though admirable for simplicity and conciseness, and though it expresses to an accomplished crystallographer already familiar with the classic works of Haüy, Levy, Weiss, Miller, Rose, and Naumann, all that can be said about the form of a crystal, yet from its very brevity, misleads the beginner. Mere figures and letters do not constitute a language, and the beginner finds, after reading over a table of measurements such as is given in Dana, he is still unable to form a clear conception in his own mind, or to express his ideas to others, for want of words to clothe them. Every form that is mentioned in such a treatise should be accompanied by a statement of the most important substances, mineral and organic, natural and artificial, where it occurs. In like manner, all the hemiedral, hemimorphic, and twin crystallizing bodies should be fully mentioned. Practical instructions should be given for the measurement and draughting of crystals, and so much of mathematics, as would enable any one with a knowledge of trigonometry to calculate the axes and forms from observed angles. The aid afforded by cleavage and the employment of polarized light in the determination of a crystal should likewise be carefully explained. Other matters, such as the deportment of the crystals to heat, electricity, magnetism, and to light in general, their hardness, the connection between the crystalline form and chemical constitution, including the topics of isomorphy and heteromorphy, all these subjects, which are generally included, might be profitably left to special treatises, and the space thus gained devoted to the actual wants of the beginner that have been mentioned above.

Beiträge zur Geshichte der Chemie. By Hermann Kopp. Braunschweig: Viewcg & Son. 1869.

The object of these contributions to the History of Chemistry is to make known the views which have been held at different times concerning the earliest pursuit of chemistry under the form of alchemy, and the earliest writers and manuscripts referring to this subject which have come down to our knowledge and possession. The learned author, with much care and toil, has rumaged amid a multitude of musty books and long-forgotten writers, and brings these records of the folly and credulity of the past to augment the volume of chemical literature of the present day, a stream so fraught

with blessing and delight to the great masses of mankind. Few chemists will have the leisure, and many will lack the ability, to read these curious philological essays, which include, among other things, the fables and theories concerning the origin and early knowledge of alchemy; opinions concerning the knowledge of alchemy by the ancients; earliest occurrence of the word Chemie; the early employment of alchemy in Egypt; the oldest chemical manuscript; the old alchemical writers in general: Democritus, Lynesias, and Zosimos. A lengthy chapter on the History of Distillation is given in conclusion. In reading the chapter devoted to the first of the topics above mentioned, we cannot but feel greatly surprised at the manner in which many passages occurring in ancient authors, were wrested from their plain and obvious meaning by the writers who came afterwards, and who wrote on alchemy, and were invested with mysterious significance. For example, the passage of Genesis, (Chap. vi. 1, 2 and 4,) "And it came to pass, when men began to multiply on the face of the earth, and daughters were born unto them, that the sons of God saw the daughters of men that they were fair; and they took them wives of all which they chose. * * * There were giants in the earth in those days; and also after that, when the sons of God came in unto the daughters of men, and they bare children unto them, the same became mighty men which were of old, men of renown." In the foregoing a tradition is regarded as substantiated which imputed a knowledge of alchemy and other mysteries to the antediluvians, on the score of their intimacy with beings of supernatural origin and powers. In juxtaposition with this passage, another is given from the book of Enoch, in the second chapter of which it is told how many angels inclined themselves to the daughters of men, and what they did in consequence; one especially, (and that nothing may be lacking to the fullness and particularity of the narrative, even his name is given,) Azâzêl, taught mankind "their arts; bracelets and ornaments, and (naughty angel!) the use of rouge and the beautifying of the eyebrows, and costly and most choice jewels and all manner of dyes, and the metals of the earth." Others of these fallen spirits taught various other heavenly mysteries, such as conjurations and astrology. The lover of classical literature can hardly fail to call to mind, in reading the above, that memorable passage in Prometheus Vinetus, in which Prometheus, who impersonates in himself the virtues of Greek mythology as Christ does those of Mosaic

origin, narrates the innumerable benefits and arts he has given to mortals. But Æschylus imputes far other and nobler motives to his sublime hero than those of an ignoble liaison. Clemens Romanus, who lived in the second century after Christ, gives both his credence and condemnation to these apocryphal accounts; and still more emphatically, Tertullian, who lived a short while later. This last-named father, in his treatise on the Education of Women, inveighs furiously against these shameless angels, not only on account of many damnable arts which they taught mankind, but particularly that they should have so corrupted the native(?) simplicity of the female portion of it, "making them acquainted with sparkling stones, by which to variegate their necklaces, and golden circles to clasp their arms, and drugs from lichens to color wool, and illud ipsum nigrum pulœrem, quo oculorum exordia producuntur!"*

Another account, referring to the connections between men and angels, is an epistle of Isis to his son Horus, that the angel Amnael had appointed to those who sought his favor, as a reward for their compliance, that he should teach them the mystery how gold and silver are made, and that he had also so done.

Among these idle stories, there is one, however, which deserves mention as a curious interpretation of an important Grecian myth in the Chronicle of John of Antioch, who is placed in the seventh or in the first half of the eighth century, is the statement: "The Golden Fleece of which tradition speaks, was a declaration written upon sheepskin, how by means of chemie to make gold."

This method of interpreting mythology was largely extended by other writers who, in their unbounded desire to lay hold on all things which might invest the subject of alchemy with portentious mystery, scrupled not to find latent meanings in many of the simply-written lines of the Iliad and Odyssey. As in that passage of Odyss. B. VIII., v. 274 to 298, which narrates the well-known story

* The following serious foot-note, appended by the author to the foregoing, is too good, in its way, to be lost. It makes one think of some of the best passages in Knickerbocker's *History of New York*. "Here and in the following places where calliblepharum tincturæ is mentioned, as previously in the book of Enoch (s. 7), reference is made to the practice, or rather the malpractice, of coloring the eyebrows with Spiessglanz (Sulphide of Antimony), and so increasing their arch (see my History of Chemistry, IV. Section, Braunschweig, 1847, s. 100). The appeasing of female vanity, which was sought by these means, was regarded as having its origin in sin, and the thing itself as sinful, just as in our own time the wearing of chignons is regarded as sinful, and is opposed by the higher authority of the church.

of the love of Venus and Mars, an old mediæval commentator discovers a certain chemical mystery in which Iron in the person of Mars, and Copper as Venus, are the principal characters. So an extract from Pindar, Olymp. IX., is cited, in which the names of a number of the gods occur, and the incident narrated is asserted to have been invented to convey to the initiated an alchemical truth: Hercules is man chemical, in common language, *common salt*, born from father acid and mother alkali; Pluto earth philosophical, *sal alkali fixum;* Neptunus *Mercurius* or *alkali volatile;* Phœbus, *Sulphur*, and so on, *ad nauseam*. One author, indeed, goes so far as to assert that all the legendary tales of Greece, Phœnicia and Egypt, relate to Chemie.

But when these writings, which were invested by mediæval alchemical writers with so much occult significance, are scanned in the light of the knowledge, philosophical and scientific, which can be made to shine upon them at the present day, all such profound meanings are found to be utterly wanting. And the same remark applies to the poems of Virgil, especially the declarations of the Sybil to Æneas, (Æneid, B. VI., v. 136,) and to the metamorphoses of Ovid, which were thought, by Petrus Bonus, Brachescus and others, to mean alchemical transformations, as well as to certain curious Latin inscriptions. There is one passage, however, which at first seems to afford good ground for supposing that alchemical processes were regarded as feasible by the Romans in the first century of our era. It occurs in the Natural History of Pliny, where it is related that avarice tempted the Emperor Caligula to command that a huge mass of orpiment should be operated upon in the manner which he had heard was practiced in Sicily for the making of gold. But the gold resulting, though excellent in quality, was of so small amount that the emperor was greatly offended. The narrative itself, however, shows that no transmutation of metals was intended, but a metallurgical process to extract from the orpiment the frequently occurring gold percentage. Passing over a succession of later authors, we come to one in whose works we find undoubted evidence that a belief in alchemy had become general. Æneas Gazaeos, a philosopher, born in Gaza, in Syria, towards the end of the fifth century, and who abandoned the doctrines of the Neoplatonists for those of Christianity. In a discourse upon the Immortality of the Soul, he says:—"Neither is it incredible that matter can be changed into a higher condition. For even among